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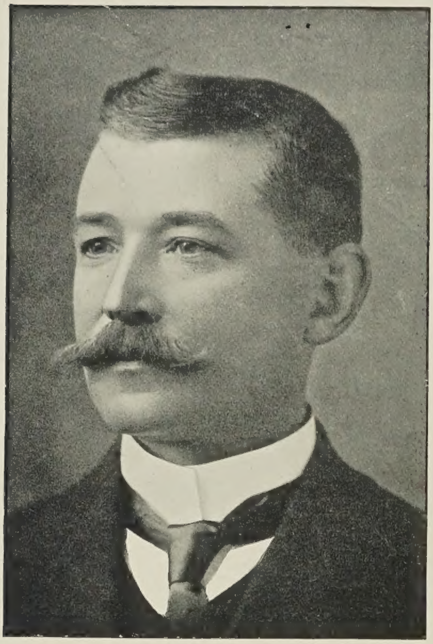
THE

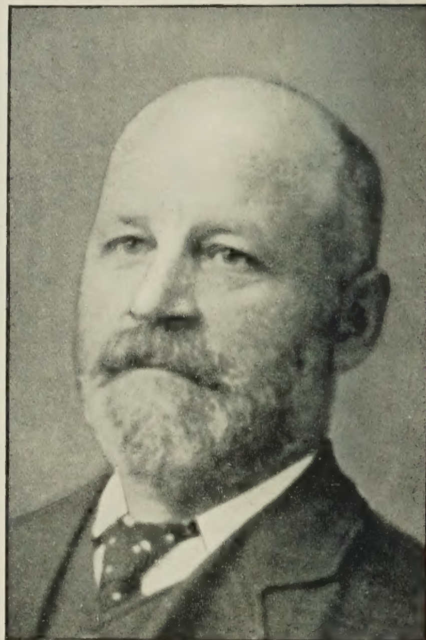
# MODERN PLUMBER

AND SANITARY ENGINEER

# LEADING MEMBERS OF THE TRADE



MR. JAMES ALGIE



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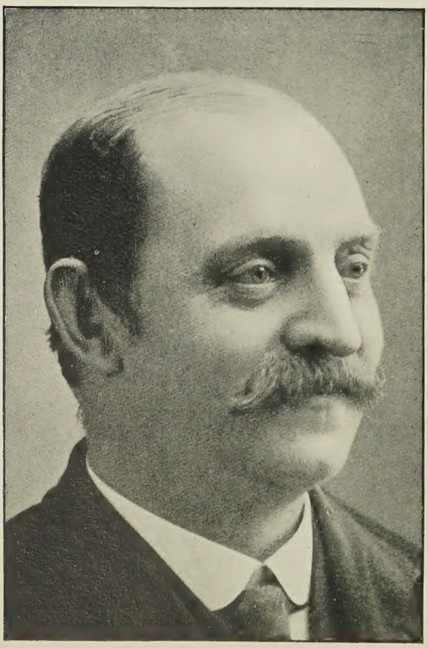
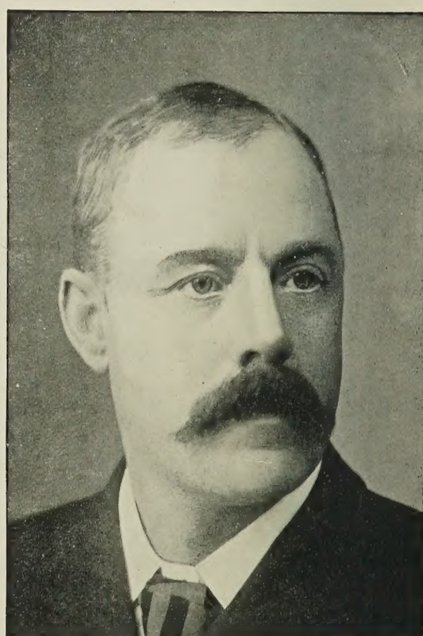


MR. EDWARD ELLIS BURNS



MR. WILLIAM CHALLONER

JAMES ALGIE, Secretary of the Operative Plumbers' Benevolent Committee, Glasgow district, obtained a certificate for technical knowledge and a Bronze Medal for practical work in plumbing from the City and Guilds of London Institute, and became a registered plumber in the year 1889. He was appointed Inspector of Drainage and Plumbing Work by the Corporation of Glasgow in 1900. He is a member of District Council for Glasgow and the West of Scotland for the Registration of Plumbers.

JOHN BEAL, born in Hull in 1851, started business as a master plumber in 1875. He was instrumental in founding the Hull Master Plumbers' Association, and took a leading part in organizing the National Association of Master Plumbers in 1895. He was president of the association in 1897 and 1898, and has since been its general secretary. Mr. Beal has also taken part in public work in Hull.

EDWARD ELLIS BURNS, born in Hamilton, Lanarkshire, in 1860, was for eleven years a plumber with the Caledonian Railway Company at Glasgow, and in 1891–1902 was a sanitary inspector for the Lower Ward of his native county. In 1902 he became General Secretary of the United Operative Plumbers' Association. Mr. Burns is Honorary Secretary of the Advisory Committee on Plumbing, which is composed of representatives from the Board of Education, the City and Guilds of London Institute, the Worshipful Company of Plumbers, the National Association of Master Plumbers, and the United Operative Plumbers' Association, and whose duty is to advise educational authorities in regard to plumbing classes.

WILLIAM CHALLONER, of Blackpool, has been since 1893 head of the firm of Thomas Challoner & Son in that town, in which he was formerly associated with his father. He is Honorary Secretary to the Education Committee of the National Association of Master Plumbers, and has taken a leading part in founding the new Institute of Plumbers. He represents his association on the Advisory Committee on Plumbing. He is an Associate of the Institution of Electrical Engineers and an Associate of the Royal Sanitary Institute.

# THE MODERN PLUMBER AND SANITARY ENGINEER

TREATING OF PLUMBING, SANITARY WORK, VENTILATION, HEATING (ELECTRIC AND OTHER), HOT-WATER SERVICES, GAS-FITTING, ELECTRIC LIGHTING, BELL-WORK, GLAZING, &c.

BY SIXTEEN SPECIALIST CONTRIBUTORS

UNDER THE EDITORSHIP OF

G. LISTER SUTCLIFFE

A.R.I.B.A., M.R.S.I.

Editor of "The Principles and Practice of Modern House Construction", &c.

WITH APPENDICES OF
TABLES, MEMORANDA, MENSURATION, ETC.

*ILLUSTRATED BY ABOUT ELEVEN HUNDRED FIGURES IN THE TEXT AND ABOUT FIFTY PLATES, MANY OF THEM IN COLOUR*

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By CAPTAIN JAMES LAW, M.R.S.I.

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BY

AN EXPERT

# Section IV

# SHEET-COPPER, ZINC, AND IRON

## CHAPTER I

### COPPER AND ZINC COMPARED WITH LEAD

**Copper.**—Although lead has in the past been regarded as the most suitable material for covering roofs of permanent buildings, and is still very largely used, it is now being superseded to a great extent by copper, which, laid on the improved methods introduced within the last few years, fully described in the next chapter, is now taking the place of lead in increasing quantities for flat roofs and moderate slopes, as it has already done almost entirely for steep slopes, spires, domes, &c.

Copper is a metal easily distinguishable by its familiar red colour, in which it differs from all other metals. It is highly malleable and ductile, and more tenacious than any other metal except wrought-iron. It is also extremely tough and durable, and by reason of these qualities it is pre-eminently suited for exterior use on buildings. It compares favourably with lead for ordinary roofing purposes, and is much superior to it for covering spires and domes and steep-pitched roofs, and for all those exposed parts of a building such as weather-vanes, finials, ventilators, &c., which, by their inaccessibility, require a specially durable material, to obviate the necessity of the erection of costly scaffolding for the carrying out of repairs or renewals.

**Its Comparative Lightness.**—Perhaps the chief advantage possessed by copper over lead, and one which will be at once admitted to be of the greatest importance, is its comparative lightness; for although its specific gravity is as high as 8·94, its extreme toughness and durability admit of its being safely used in very thin sheets. No. 24 Birmingham Wire Gauge sheet-copper weighs only 1 lb. per superficial foot, and will provide a thoroughly durable roof-covering, whereas, to obtain a similar result in lead, the sheets would have to weigh 7 lb. or even 8 lb. per superficial foot. From this it is apparent that a very considerable saving can be effected in roof timbers and supports by using copper in place of lead. No. 23 B.W.G. sheet-copper weighs 19 oz. per superficial foot, and is used on public buildings and institutions, or where economy is not of the greatest importance.

**Its Durability.**—The extreme durability of copper was recently illustrated, when it became necessary to renew the copper on a church roof. The metal had been originally very badly laid, no allowance having been made for expansion, with the result that it had split in many places. The bulk of the metal, however, was found to be practically unimpaired, and would certainly not have required renewing if it had been properly laid in the first instance. Unfortunately there is no exact record of the date when this roof was covered, but it is certain that it was previous to 1760, the copper having therefore been exposed on the roof for about 150 years.

**Expansion and Contraction.**—Copper possesses two other favourable features in its low proportion of expansion and its high melting-point, the latter being so high as to render the metal practically fireproof. In copper the ratio of expansion between 32° and 212° F. is ·0018, whilst that of lead is ·0028, and that of zinc ·0029.

This low proportion of expansion and contraction is a very great advantage in laying the metal, and makes it possible to welt copper sheets together on a roof in a way which would be impossible with either lead or zinc, either of which materials would quickly be torn and split unless a much larger allowance was made.

There is, further, always a tendency for lead, on account of its great weight and the softness of its texture, to "creep" out of position, in the course of time, especially on steep slopes and on domes and spires. Copper, on the other hand, because of its lightness and tenacity, can be relied upon to remain in position when it has once been properly fixed. In this connection it may be mentioned that the lead on the roof of Bristol Cathedral, which is of moderate pitch, crept down to the astonishing extent of 18 in. in two years (see Tyndall on *Heat considered as a Mode of Motion*). The explanation is that the amount of expansion effected by the heat of the sun, which is assisted by the force of gravity, is prevented, by the same force, from being recovered by contraction in the coolness of the night.

**The melting-point** of copper is 1950° F., while that of lead is only 612° F., and that of zinc 736° F.

The advantage of the high melting-point of copper in the case of fire is obvious. A building roofed with copper is quite immune from catching fire from burning timbers falling on the roof from an adjacent building. Moreover, if the fire originates in the building itself, the copper roof will in many cases confine the flames, and be very little affected, the metal, perhaps, only softening a little here and there in a very intense heat. A lead roof under similar circumstances will quickly melt, and a zinc roof will catch fire and burn fiercely.

**The Cost of Copper and Lead.**—The large amount of copper now being used is evidence of the fact that its excellence as a permanent building material is now more fully recognized, but it is frequently thought that the cost of the metal is too great for its extensive use on ordinary buildings. At first sight this would appear to be correct, especially when the market price is compared with the prices of lead and zinc. The price of copper fluctuates very much, and during the year 1906 it advanced from £95 to

£120 per ton. On a certain date, the price of sheet-copper was £105 per ton, while that of zinc was £32 per ton, and that of lead £19. These figures represent the actual first cost to the merchant for large quantities, but will serve for purposes of comparison. They show that the price of copper is between five and six times that of lead, but when it is remembered that 1 ton of 24-gauge copper will cover the same area as 6 tons of 6-lb. lead or 7 tons of 7-lb. lead, the apparently expensive metal is seen to be cheaper than lead.

Taking these prices as a basis, we find that the two metals give the following results:—

1 cwt. of 8-lb. lead (costing, say, £1) will cover 14·00 ft. super.
1 „ „ 7-lb. „ „ „ „ „ 16·00 „ „
1 „ „ 6-lb. „ „ „ „ „ 18·66 „ „
21 lb. of 24-gauge copper (costing the same amount) will cover 21·00 ft. super.

In these figures no allowance is made for laps, rolls, welts, &c.

It must also be remembered that the durability of 24-gauge copper is at least as great as that of 7-lb. lead, and that the cost of laying copper is in no way excessive, varying between 2*d.* and 2½*d.* per superficial foot when laid by men properly trained to the work.

In calculating the amount of copper required to cover a given area as compared with lead, a saving can also be reckoned upon in the amount of metal required at the drips and rolls, the low proportion of expansion and contraction admitting of a minimum amount of metal being used at these points. The amount saved in this way usually works out at about 5 per cent.

In addition to this saving there remains to be considered the economy which can be effected in the roof timbers, the comparative lightness of copper permitting the use of smaller scantlings than those required by lead.

In a large job recently carried out by an eminent architect, competitive prices were obtained for 24-gauge copper (1 lb. per superficial foot) against 6-lb. lead, and the prices for the former were found to be approximately 10 per cent less than those for the lead. The architect expressed considerable surprise at the result of the tenders, and also satisfaction at being able to use the copper. This goes to show that the idea generally entertained that copper is more costly than lead is quite erroneous, and that it can be easily dispelled by comparing estimates for the two metals as applied to the same job.

**The Price of Copper.**—While comparing the respective costs of copper and lead, it may not be out of place to mention that the present price of copper is a very high one, and is held by many to be in a large measure the result of market manipulation, and that the price may at any time fall rapidly to its normal figure of about £75 per ton. It is true that for twelve months the market price of sheet-copper has not been below £95 per ton, and that the great demand for the metal for electric railways and other large works may keep the price at its present high level for some time, or even send it considerably higher; but there is not the least doubt

that this record price of the metal has stimulated production very considerably, and many prospective large copper-producing properties are being pushed forward with all possible speed towards the producing stage, in order to take advantage of the present high level of prices.

The prospects for the future seem to be that, even assuming that the present price is not the result of market manipulation, but is a legitimate price caused by the excessive demand for the metal, the increased supply which is likely to be soon available will bring the price back to its normal level of about £75 for sheet-copper, or about £65 for standard copper, at which price it can still be very profitably supplied to the market by the mines.

For the moment, and until these new supplies are available, the huge annual consumption for the whole world, which now exceeds half a million tons, prevents any accumulation of stocks, which at the present time often represent only one month's supply, and rarely exceed three months' demand. As soon as these stocks can be increased, and a larger amount of the metal kept on hand, the price must fall.

Generally speaking, it takes five years to bring a copper mine to the stage of producing copper in any quantity, but unlike many other metals it is generally found that where copper exists at all it proves to be in very large deposits.

**The chief copper-producing countries** are the United States of America, which supply 60 per cent of the whole world's consumption, and Spain and Portugal (supplying about 10 per cent); smaller quantities in the order named are obtained in Mexico, Japan, Australia, Chile, Germany, and Canada. Newfoundland and Cape Colony also contribute to the world's supply of copper, and Rhodesia will also most probably become a large producer in the near future.

It is interesting to note that Great Britain in 1830 supplied half of the total world's consumption of copper, but in 1860 it had dropped to second place, supplying about 16,000 tons, and now the annual output is only about 500 tons.

The United States of America, on the other hand, supplied in 1850, 572 tons; in 1870, 12,600 tons; while to-day the American output exceeds 300,000 tons.

Great Britain, although her supply is no longer considerable, still holds first place in consumption, taking about 140,000 tons, the United States taking about 120,000 tons, Germany about 70,000 tons, and France about 43,000 tons per annum.

**Zinc.**—Turning to zinc, we find that this metal has one advantage, and one only, over lead and copper for exterior use on buildings—its cheapness; but zinc is not a durable metal, and is not used on buildings of a permanent character. It is the favourite material of the speculative builder, and has been recently described in a pamphlet on roof-coverings (issued by the Society for the Protection of Ancient Buildings) as "spreading like a pest over the country". It nevertheless fulfils a very useful purpose, and for buildings of a temporary character, or where cheapness is a *sine quâ non*, it can be used with advantage.

**The cost of zinc** laid on roofs is, roughly speaking, one-third that of copper or lead, but, the life of the metal being considerably less than one-third that of the more expensive materials, it cannot be considered economical if used on permanent buildings. The cost for plain work is about $6\frac{1}{2}d.$ per superficial foot. The gauges in general use are—

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| No. 14 gauge | equal | to about | No. 21 | B.W.G., | and weighing | about | $18\frac{3}{4}$ | oz. | per sup. ft. |
| No. 15 | ,, | ,, | No. 20 | ,, | ,, | ,, | $21\frac{3}{4}$ | ,, | ,, |
| No. 16 | ,, | ,, | No. 19 | ,, | ,, | ,, | $24\frac{3}{4}$ | ,, | ,, |
| No. 17 | ,, | ,, | No. 18 | ,, | ,, | ,, | $27\frac{3}{4}$ | ,, | ,, |
| No. 18 | ,, | ,, | No. 17 | ,, | ,, | ,, | $30\frac{3}{4}$ | ,, | ,, |

In the writer's opinion Nos. 15 and 16 gauges are the best of these, as at 17 gauge and over the metal is difficult to work and is liable to crack in turning up the sheets. These gauges can be relied upon to last about twenty or twenty-five years, if properly laid and the necessary allowance made for expansion and contraction. After this lapse of time the metal becomes porous through the action of the atmosphere. It is somewhat remarkable that paint is very rarely used to preserve zinc. There is, of course, the cost of painting to be considered, but the life of the metal may be prolonged almost indefinitely if painted, say, every five years. This should not be very costly if carried out when the other exterior work of a building is painted, and would, of course, only apply to flats or places where the metal is easily accessible.

**The Question of Appearance.**—*Before concluding the comparison of the three metals, there is one more stand-point from which they may be viewed. It is perhaps of minor importance compared with the questions of weight, cost, and durability, but it is worth consideration; we refer to appearance.*

Unlike the practice in Eastern countries, where the roofs of buildings are generally concealed and used by the occupiers when seclusion is desired, the roofs of buildings in more northern climes are almost invariably conspicuous parts of the structure, and it is therefore a distinct advantage to employ a material which shall have some decorative effect and, instead of being unsightly, add as far as possible to the beauty of the structure. In any position, except in the heart of London and other large cities, copper has a very real advantage over the other metals in the beautiful blue-green colour it assumes after the lapse of a very few years. York cathedral and the Paris Opera House are well-known examples where the use of copper has greatly added to the beauty of the buildings, producing a splendid decorative effect entirely unaided by artificial means. The effect, moreover, is one which cannot be produced artificially.

Unfortunately this colour is lost, as already stated, in the heart of London, but the spire of the old parish church at Hampstead is a good example not far removed from the city smoke. Another beautiful example is the spire of North Mimms church in North Mimms Park, near Hatfield, Herts.

This colouring matter partly accounts for the extreme durability of copper, as it is actually a thin layer of basic carbonate of copper, known as the "patina", which, when once formed, protects the metal from the further

action of the atmosphere. For this reason, in London and other large cities, where in any case the beautiful colour would be lost, and where the excessive amount of sulphur and other impurities in the atmosphere (including, perhaps, destructive chemical products from adjacent factories) subjects the metal to a very severe test, it is advisable to tin the sheets before laying, in order to protect them against atmospheric action. This subject will be more fully dealt with in a later chapter.

**The Ideal Metal for Exteriors.**—It may be well to enumerate the essential attributes of the ideal metal for exterior use on buildings, and to see to what extent they are possessed by the three metals under comparison. The essentials are: 1, durability; 2, lightness; 3, adaptability; 4, a low proportion of expansion and contraction; 5, a high melting-point or capability of resisting fire; 6, toughness of texture or tenacity, and ability to retain its position when fixed; 7, moderate cost; and 8, a good appearance.

If it be admitted that these eight qualities supply the desiderata in an ideal metal for external use on buildings, we are forced to the conclusion that copper is the only one of the three which possesses all the qualities in a high degree. Zinc compares favourably with copper and lead in none of them except cost, and it can be taken for granted that, if copper should ever become so much cheaper as to approximate to the cost of zinc, the use of the latter metal would be quickly discontinued. There is, however, small likelihood of this occurring, and while the cost of copper remains about three times that of zinc, there will always be a strong demand for the latter.

With regard to lead, we find that it possesses the first essential—durability—in a high degree, but fails in the second, its great weight being the chief objection to its use. It also possesses the third essential, of adaptability, but in excess, the softness of its texture, combined with its great weight, often causing it to "creep" out of position when employed on steep slopes, domes, or spires. In essentials No. 4—a low proportion of expansion and contraction—and No. 5—a high melting-point—it again fails. With regard to its cost compared with copper, there is really very little to choose between the two metals. There is, in many cases, a small advantage, as we have already seen, in favour of copper, but this difference would probably not be sufficient to influence its use, did it not possess the other more striking advantages enumerated.

Probably the principal reasons for the continued use of lead are that the metal can be very easily worked into various shapes, and applied to a great variety of purposes, and, more especially, that every plumber has been trained to manipulate the metal and possesses the necessary tools. Working in copper, on the other hand, is at present somewhat of a speciality, and comparatively few men are proficient in it. Every large village has its plumber, and small works can be carried out by him in lead at a less cost than would be entailed by the use of copper, laid by special men from a distant town.

# CHAPTER II

## PLAIN AND ORNAMENTAL COPPER ROOFING

**Roof-boarding.**—The first essential for a good copper roof is properly-prepared wood-work. The boards should be 1 in. thick (although $\frac{3}{4}$ in. boards are often used), and be laid with an even face lengthways with the current, and with a fall of not less than $\frac{1}{4}$ in. to the foot.

Much trouble has often been caused when the boards have been laid across the current, and when sufficient care has not been taken to ensure an even face, a board slightly thicker than the rest being allowed to stand up above the others here and there; on flat roofs this destroys the fall and permits the water to remain in pools, as the thin metal naturally "gives" to the surface of the wood-work. If the boards are laid with the current, although it is still advisable to maintain an even face, any irregularity in the thickness of the boards is not an obstacle to the free passage of the water down the roof.

A method of boarding very often adopted is to lay the boards diagonally, and while this is not so good a plan as laying the boards with the current, there are many cases where, by the construction of the roof, the latter arrangement cannot be obtained without considerable extra timber and consequent expense, and in these cases diagonal boarding offers a very fair compromise, and is certainly better than boarding laid across the current.

**Felt.**—Before laying the copper the boards should be covered with felt secured with copper nails. Unfortunately iron nails are often used, but this practice is strongly condemned, as there is always a probability of the iron nails rusting and affecting the copper detrimentally.

Felt laid between the boarding and the copper covering serves several useful purposes. It helps to keep living rooms under a roof cool in summer and warm in winter, and also prevents the heat of the sun from penetrating the metal covering and causing the boards to twist. A consideration, perhaps greater than either of these, is that it deadens the sound of a heavy rain falling on the roof, which has often been a ground of complaint. The writer had a complaint of this nature brought to his notice a short time ago. In this case the lead roof of a church had been replaced with copper, which had been laid without felt, with the result that when a heavy rain was falling, the noise inside the church was sufficient to interrupt the services; indeed, the annoyance caused by this omission was so great as to make it necessary to strip the roof again and relay the metal on felt. For these reasons felt should always be used on the boarding of a roof intended for a copper covering, although it is in no way necessary to the efficiency and durability of the roof, carefully prepared wood-work with all nails well punched in being a sufficient foundation from this point of view.

**Protection during Progress of Work.**—In laying copper on flat roofs there is of necessity a considerable amount of traffic over the metal during the progress of the work. There is also invariably an accumulation of brick rubbish, nails, &c., which, unless frequently removed, are very liable

to be trodden into the metal, causing considerable damage. The soft, yielding nature of the felt admits of hollows being easily formed in the metal, when any hard substance is trodden-in in this way. It is important, therefore, that the flat should be constantly swept during the execution of the work, and the surface of the metal left perfectly smooth, with no depressions in which the rain can collect in its passage down the roof.

**"Stand-up Welt" System.**—The first method with which we will deal—which is also the oldest—is that known as the "stand-up welt" system. It is carried out without the use of wood rolls, and is to some trifling extent cheaper than any other method, the amount of metal required for covering the rolls and the wood-rolls themselves being saved. It is not, however, a good method and is now almost wholly discontinued.

Plate X shows a flat laid on this principle; the sheets are all welted together at the sides, and secured by clips $1\frac{1}{2}$ or 2 in. wide (see section at A), nailed to the boards about 3 ft. apart, and worked into the stand-up welts. If drips are required they must be as shown at B, Plate XI, and $1\frac{5}{8}$ in. deep, and where the minimum fall of $\frac{1}{4}$ in. to the foot is used, they are 10 ft. apart, but the distance can be increased to 15 ft. or 20 ft. where a slightly increased fall can be obtained.

The objection to this stand-up welt system is that insufficient allowance is made for expansion and contraction, and there is a tendency for the copper to come up in blisters and tear away from the clips.

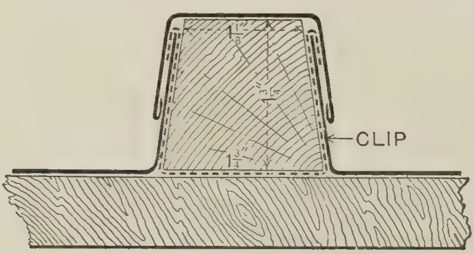


Fig. 187.—Wood Roll and Copper Roll-cap

**Wood-roll System.**—The first improvement on the stand-up welt was effected by the introduction of wood rolls (fig. 187), the use of which ensures the necessary provision for expansion and contraction. These rolls measure $1\frac{3}{4}$ in. at the base and $1\frac{1}{8}$ in. on the top, and are $1\frac{3}{4}$ in. deep; they are skew-nailed to the boarding, and clips for holding the sheets in position are fixed under them about 3 ft. apart. The use of these rolls necessitates a $2\frac{1}{2}$-in. drip, instead of the $1\frac{5}{8}$-in. drip which is possible on the stand-up welt system. The sheets in general use measure 5 ft. 3 in. by 2 ft. 8 in., and admit of the wood rolls being placed 2 ft. 6 in. from centre to centre; while two sheets seamed together give a length of 10 ft. between the drips. The sheets are turned up against the roll, and covered with a roll-cap as shown in fig. 187.

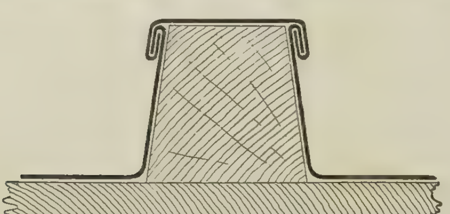
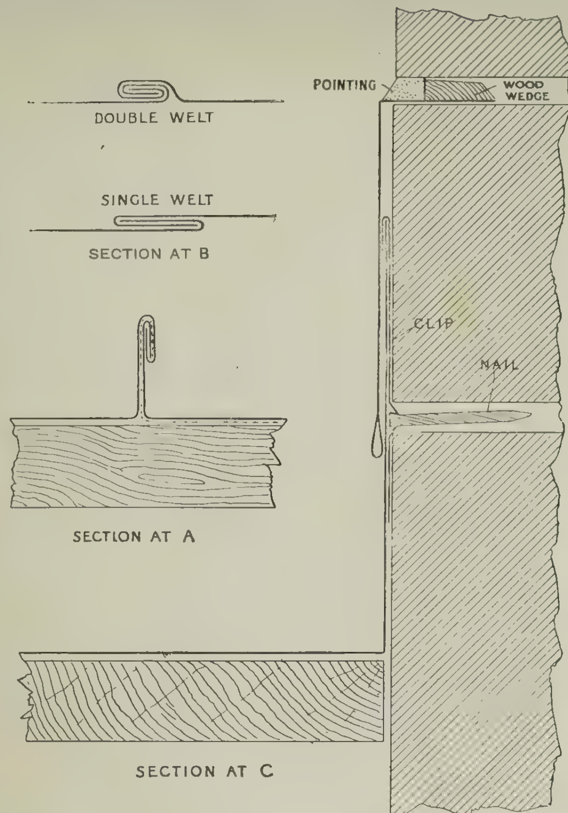


Fig. 188.—Wood Roll and Seamed Copper Roll-cap

A further improvement is made on this system by "seaming-on" the caps to the sheets, as shown in fig. 188. This makes a very much better job, and gets over the drawback





"STAND-UP WELT" SYSTEM OF COPPER ROOFING

of a loose cap, while still leaving sufficient margin for expansion and contraction.

**Conical-roll System.**—The latest and undoubtedly the best method for laying copper is that known as the conical-roll system, which was introduced and patented by Messrs. Ewart & Son, Limited, about the year 1902. As its name implies, the feature of this method is the shape of the roll, which is conical with slightly rounded top, and the advantages will be obvious. The size of the roll is $1\frac{3}{4}$ in. at the base, and $1\frac{5}{8}$ in. deep. This admits of a drip $1\frac{5}{8}$ in. deep, as in the stand-up welt system, and effects a saving in both metal and timber over the ordinary square-roll systems. The cap is entirely abolished, the sheets being joined by a single welt on the side of the roll.

Plate XI shows a flat laid on this principle, and the detail at A is a section of a roll showing the method of joining the sheets. The conical rolls are fixed 2 ft. 5 in. from centre to centre, and the length of the drips, as in the other systems, is usually 10 ft., the standard sheets measuring, as already mentioned, 5 ft. 3 in. by 2 ft. 8 in. There are also what are known as "Scotch" sheets, which measure 4 ft. by 3 ft. 6 in., and a few sheets of this size are very often used on a job, as they are found useful for working round chimney stacks and openings in the roof. It will be noted that each of these sheets contains 14 superficial feet. The standard size is in every way the most suitable and is nearly always used, but sheets can be obtained, if specially ordered, of any dimensions provided that the total area does not exceed 14 superficial feet.

Another feature of the conical-roll system is the patent *stop-and-saddle piece.* These are welted on to the sheets at the drips, and make a very simple and effective joint. (See Plate XI.)

**Welts.**—A copper roof should be laid entirely without solder, and this can be effected if the roof is carefully set out and the drips properly arranged with regard to the openings in the roof. The contractor for the copper-work is generally consulted on this point, and the details of the wood-work carried out to suit the requirements of the metal. The sheets are joined by welts or seams, which are of two kinds—single and double (fig. 189). The single welt is used on the rolls, and the double welt is always employed to join the 2-ft.-8-in. sides of the sheets between the rolls, across the current. The thickness of the welts is exaggerated in the drawing for the sake of clearness. With regard to these double welts, it is usual in laying the sheets to break the joints across the bays as shown in Plate XI; the reason being that, as the sheets vary slightly in length, a better appearance is obtained by this plan, and any variation is not then noticeable, as it would be if an attempt were made to keep the joints in a line.

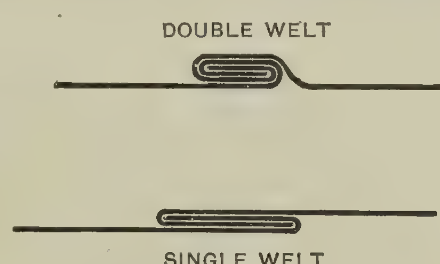


Fig. 189.—Single and Double Welts (full size)

**Flashings.**—The detail at C, Plate X, illustrates the method employed for

copper flashings. The sheets are turned up about 4 in. against the wall, and are held in position by clips about $1\frac{1}{2}$ in. wide, nailed into the brickwork, and having the top edge turned over to receive the ends of the sheets. The apron is about $3\frac{1}{4}$ in. on the face, and is inserted into the brickwork about $1\frac{1}{4}$ in. The top edge has a half-turn up as shown, and is wedged in with oak wedges. These wedges are driven well into the brickwork and concealed by the cement pointing, which protects them from the weather, and prevents them from being drawn out by the heat of the sun.

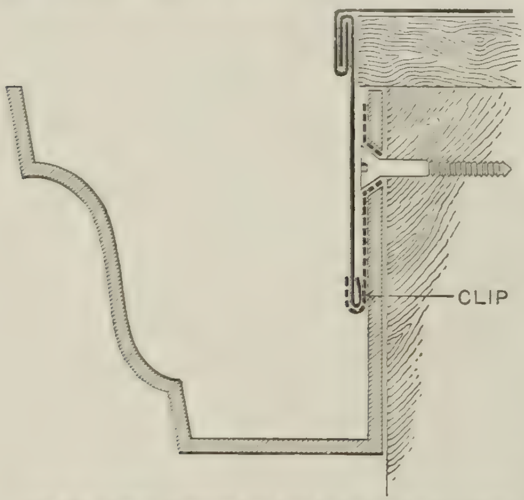


Fig. 190.—Copper Flashing into Iron Gutter (one-half full size)

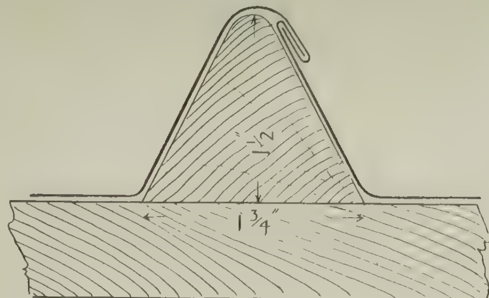
Fig. 190 shows the method of finishing a copper flat into an iron gutter, an apron-piece being welted on to the ends of the sheets, and held in position by clips fixed with screws as shown. A thoroughly water-tight joint is thus obtained.

**Pitch Roofs.**—Wherever a greater fall than $1\frac{1}{2}$ in. in a foot is obtainable, the conical-roll system is employed in exactly the same manner as described for flats, with the exception of the drips, which can be dispensed with and

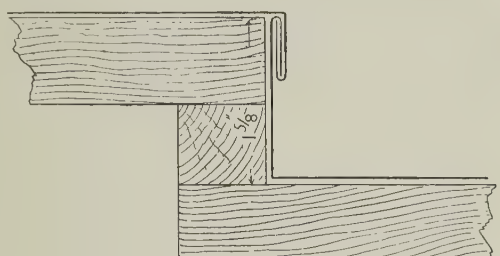

Fig. 191.—Copper Pitch-roof with Copper Vases, Finials, &c.

the sheets joined by double welts to any length required. This also applies to roof gutters.

Fig. 191 is an illustration of a pitch roof of copper, together with some interesting ornamental work, on the Sun Fire Office, Newcastle-on-Tyne, recently executed by Messrs. Ewart & Son, Limited. The three vases and the sun and its rays are formed in copper. The face of the sun is 3 ft. in




Section at A




Section at B


EWART'S PATENT "CONICAL ROLL" SYSTEM OF COPPER ROOFING

diameter and the rays 16 ft. from point to point, and these, together with the flames rising from the vases, are gilded.

**Tinned-copper Roofs.**—It has already been mentioned that under certain conditions, especially in London and other large cities, it is advisable to tin the sheets of copper before laying them. This is not very frequently done, as it adds to the cost of the work, which is perhaps already high enough, but the practice is certainly a good one where the extra expense would

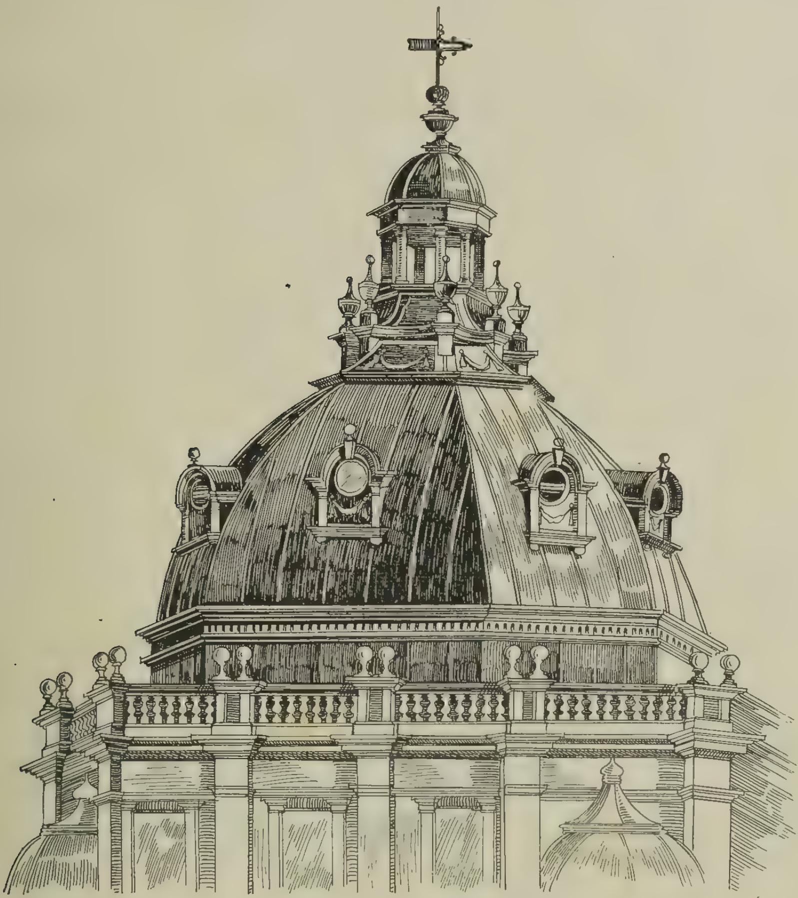


Fig. 192.—Copper Dome, Regent House, London

not be objected to, and a roof covered with this material is practically imperishable.

It was used many years ago on a country church, when it became necessary to renew the roof-covering of one aisle. The old covering was lead, but upon stripping this it was found that the roof timbers had deteriorated so considerably that they were judged to be unfit to carry the weight of lead required. It was therefore decided to substitute copper, and the sheets were tinned in order to match as nearly as possible the lead roof of the other aisle. The copper used was 23 gauge (19 oz. to the superficial

foot), and it was tinned on both sides. The tinning of the under side of the copper was not, of course, necessary, but was done to save time, the process of tinning the sheets by passing them through a bath being much quicker than tinning on one side only, and the cost of the extra tin being saved in the labour. This roof was recently inspected and the substance of the metal was found to be as perfect as the day it was laid.

**Copper Domes.**—Fig. 192 represents a plain octagonal copper dome on Regent House, London carried out by Messrs. Ewart & Son, Limited. The

Fig. 193.—Dome of the New Sessions House, Old Bailey, London

dome is about 40 ft. in diameter, and the fluted cornice at the base, the dormers, lantern, and vane are all in copper.

Fig. 193 is an illustration of a very fine copper dome surmounted by a figure of "Justice", the figure being gilded. This work has been recently carried out by Messrs. F. Braby & Co., Ltd., on the New Sessions House, Old Bailey, from the designs of Mr. E. W. Mountford, F.R.I.B.A. The dome is 25 ft. high and 34 ft. in diameter, and the figure (including the base) is 22 ft. 6 in. high and 15 ft. from hand to hand, and the sword held in the right hand of the figure is 7ft. 6 in. long.

Fig. 194 shows a section of a roll suitable for domes of this kind.

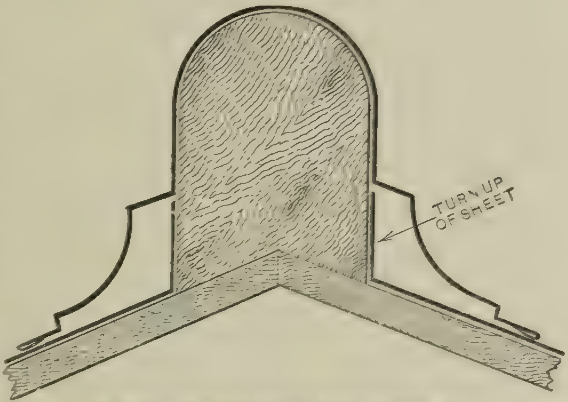


Fig. 194.—Moulded Copper Rib for Domes, &c.

**Ornamental Copper Roofing.**—By the process of stamping, and thus closing the grain of the metal, copper becomes stiff and hard, and can be relied upon to retain its shape when used for mouldings or ornaments of any description. No. 23-gauge sheet-copper, weighing 19 oz. to the superficial foot, is generally used for ornamental work. It is very largely used stamped into tiles, either plain or embossed to any design, and when so used on a dome or spire, with the tiles diminishing in size upwards in proportion to the reducing diameter, a very good effect is obtained. Fig. 195 shows the dome of the new Gaiety Theatre in the Strand, London, and is a good example of this class of work. The main ribs contain panels which are filled with stamped copper tiles, and the intermediate spaces have moulded ribs forming panels.

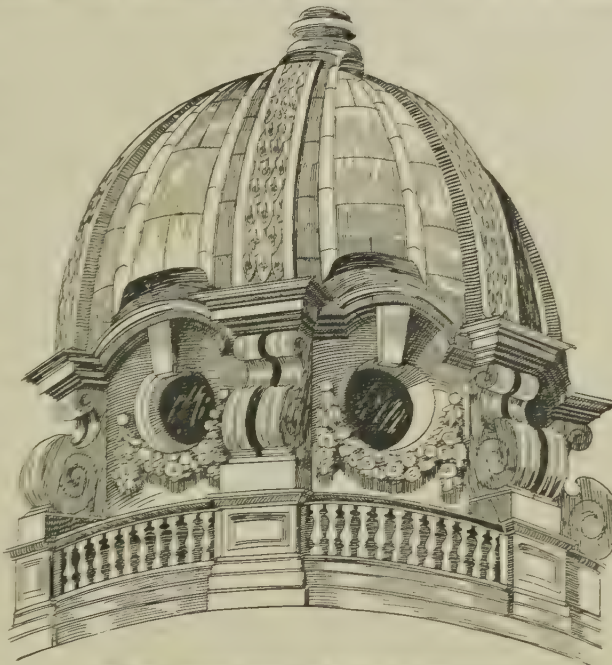


Fig. 195.—Copper Dome, new Gaiety Theatre, London

It may not be out of place to mention here that copper roofing, both plain and ornamental, requires fixing by men specially trained to the work, and should be placed in the hands of one of the firms who make a speciality of this work. Copper tiles especially require very careful fixing to ensure their retaining their position. They are fixed with screws which are entirely covered by the tiles and protected from the action of the weather.

The process of stamping is carried out by first making in plaster a model of the tile or other ornament required, from which two castings are

made—one in zinc and one in lead. The lead casting has the pattern sunk, and on this the copper to be stamped is laid. The zinc casting has the pattern raised, and has four bolts cast in with the metal; this is bolted to a heavy hammer, which is worked in a similar manner to that employed for pile-driving, and is so arranged that the raised pattern on the zinc casting falls exactly into the corresponding sinkings in the lead die below.

Ornamental figures are made to any size in sections in this way, as also are dormer fronts, and for both of these purposes copper is specially suited on account of its lightness, the ease with which it can be fixed and the light supports necessary, and its ability to retain permanently the exact shape into which it is stamped, and the position in which it is fixed.

Ornamental rolls for domes and hips, and other mouldings and enrichments, are also stamped on this method.

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# CHAPTER III

## ZINC ROOFING

**Selection of Sheets.**—The commercial name for zinc, before it is rolled into sheets, is "spelter", and the quality of the sheets depends upon the purity of the spelter from which they are rolled, and its freedom from other metals.

Iron especially is very detrimental, and if present in any appreciable quantity, quickly acts upon and destroys the zinc. The best quality sheet-zinc obtainable is that known as V.M., which is supplied by the Vielle Montagne Zinc Company of Belgium, and the following analysis shows that their spelter is practically pure zinc:—

| | |
|---|---|
| Zinc ... ... ... ... | 0·995 |
| Iron ... ... ... ... | 0·004 |
| Lead, &c. ... ... ... ... | 0·001 |
| | 1·000 |

The amount of alloy is here infinitesimal, and the zinc is as nearly pure as possible. Absolutely pure zinc is not obtainable commercially.

Great care should be exercised in the selection of the sheets for roofing purposes, as there are, unfortunately, many inferior brands of sheet-zinc on the market at slightly lower prices. Good sheet-zinc is even and light in colour, and will bend backwards and forwards easily without cracking. Inferior zinc is darker in colour and has a mottled appearance, caused by the presence of alloys of other metals, and is liable to crack when bent.

**Boarding.**—Roofs intended for covering with zinc require the same preparation with regard to the boarding that has already been mentioned as necessary for copper, viz., that the boards should be laid with an even face lengthways with the current. This is a detail that is very frequently omitted in zinc-work. It is more or less general to take some care in the preparation of a roof intended for a lead or copper covering, but

anything is very often considered good enough for zinc, and boards of the very roughest description and of varying thickness are used. This is a very great mistake, and would probably occur less often if its importance were realized. The extra cost of laying the boards properly is trifling, and the gain in the increased life of the metal, especially if there is any traffic over the roof, is very considerable.

**Sizes of Sheets.**—The sheets in general use measure 8 ft. by 3 ft., but they are sometimes used 7 ft. by 3 ft. There is also what is known as a 10-ft. sheet, but this really measures 9 ft. 10 in., and admits of a length of 9 ft. 3 in. between the drips. When the 8-ft. sheet is used, the drips are 7 ft. 5 in. apart, and with the 7-ft. sheet, 6 ft. 5 in. The depth of the drips is $2\frac{1}{2}$ in. in each case.

**Soldering.**—Theoretically, all zinc-work should be laid without solder. In practice, however, it is generally found that in working around openings in a roof, necessitating the insertion of gussets, it is impossible to avoid its use altogether; but it should be used only where absolutely necessary, and great care should be exercised. There is a small detail in connection with this part of the work which is often overlooked with disastrous results, and which the writer believes to have been the cause of trouble on several occasions. In soldering, the zinc-worker, of course, uses a copper-bit, which is continually being cleaned with a file, and these fine copper filings, if left on the zinc-work, set up (when there is rain) a galvanic action, which quickly eats through the zinc, leaving tiny perforations through which water readily finds its way. A case of this sort recently came under the writer's notice. A flat had been laid in 16-gauge zinc, and after a few years, but long before the metal should have been worn out, a complaint was received that the roof was leaking. A very careful examination was made, and it was found that although the larger portion of the flat was perfectly sound, one or two of the sheets, when taken up and held to the light, were perforated in this manner, as many as seventy small holes being found in one sheet, the rest of the sheet being of the proper gauge and in good condition. It is, of course, difficult to prove this theory, but it is also difficult to conceive any other explanation of a defect of this description.

In any case the necessity of keeping the surface of the metal constantly swept during the laying, as already mentioned with reference to copper, is emphasized. The remarks with regard to the use of felt under copper apply equally in the case of zinc.

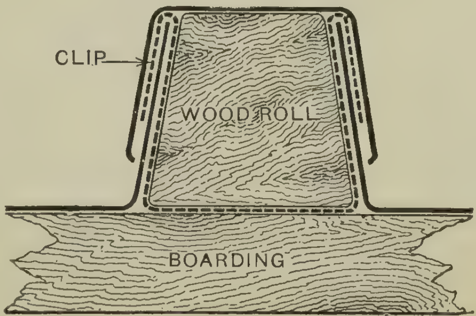

Fig. 196.—Wood Roll and Loose Cap for Zinc Roofing

**Rolls.**—The rolls measure $1\frac{3}{4}$ in. at the base, $1\frac{1}{4}$ in. at the top, and $1\frac{3}{4}$ in. deep, the angles being rounded, and are skew-nailed to the boarding 2 ft. $10\frac{1}{2}$ in. from centre to centre, with clips underneath about 2 in. wide and 3 ft. apart for holding the

sheets in position. For flat roofs the minimum fall is again $\frac{1}{4}$ in. to the foot, and wood rolls are used as shown in fig. 196. The sheets are turned up against the rolls, and the clips turned over the edges of the sheets; the

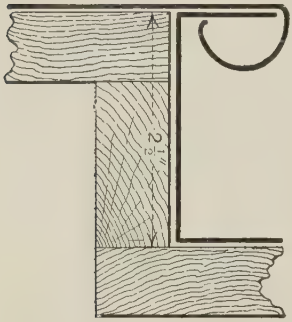


Fig. 197.—Drip in Zinc Roofing

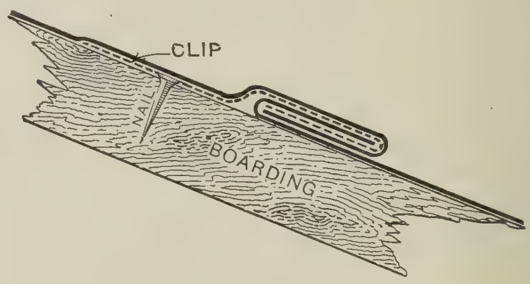


Fig. 198.—Welt for Sloping Zinc Roofing

roll is then finished with a loose cap, which leaves the sheets perfectly free to expand and contract.

Originally the ends of the rolls were covered by pieces soldered on, but this is now entirely discontinued in favour of the solid stop-ends and saddle-pieces, which make a thoroughly water-tight joint, without solder, and allow sufficient play for expansion.

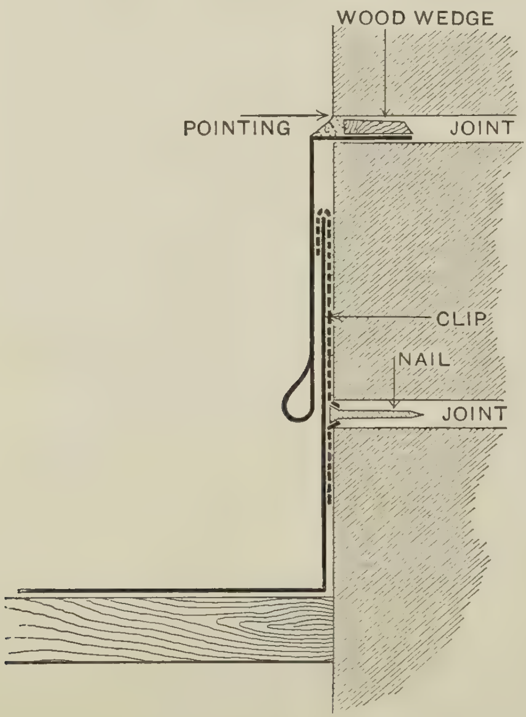


Fig. 199.—Zinc Flashing against Wall

**Drips and Welts.** — The drips on flat roofs are $2\frac{1}{2}$ in. deep, and the zinc sheets are bent and fitted together as shown in fig. 197.

If a roof has a fall of $1\frac{1}{2}$ in. in a foot, or more, drips can be entirely dispensed with, the ends of the sheets being joined with a fold or welt, with clips about 2 in. wide inserted, as shown in fig. 198.

**Flashings.**—Zinc flashings (fig. 199) are carried out much in the same manner as lead flashings. The sheets are turned up 6 in. against the wall, and the apron should be 4 in. on the face, and inserted $1\frac{1}{2}$ in. into the wall and pointed with cement, the bottom edge of the apron being stiffened by a bead. Clips are nailed to the walls as shown to keep the upstand in position.

Fig. 200 shows the method of finishing a zinc flat into an iron gutter, the apron being kept in place by clips fixed with screws to the woodwork.

**Corrugated Zinc.**—Where a very cheap job is required, the cost of the roof-boarding can be saved if the zinc is stiffened by corrugations. There are two methods employed. In the first, the corrugations are about $3\frac{1}{2}$ in. wide and are close together, and the sheets are laid on purlins fixed about 2 ft. 6 in. apart, in the same way as corrugated iron. The sheets overlap at the sides, and are screwed to the wood-work at the top and bottom edges, the corrugations running parallel with the slope of the roof. All screws should be fixed on the top of the corrugations, so that they throw off the water, and small washers are sometimes placed under the heads of the screws.

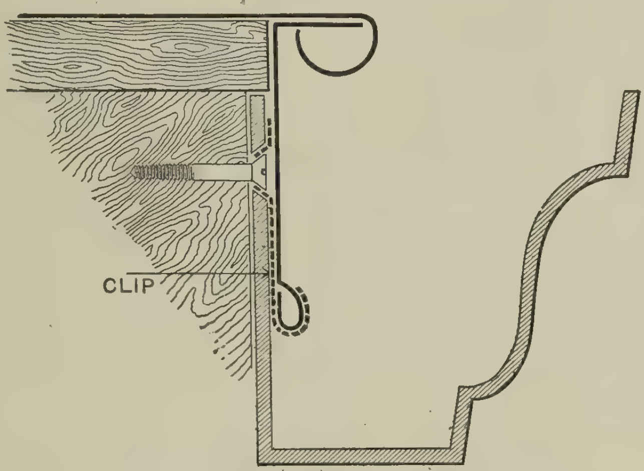

Fig. 200.—Zinc Flashing into Iron Gutter (half full size)

The second, and the better method, is known as the Italian corrugated-zinc roof, and is fixed as shown in fig. 201.

On this plan the corrugations are arranged at wider intervals, being 1 ft. 3 in. from centre to centre, and the sheets are fixed on rafters at similar intervals, the tops of the rafters being rounded to fit into the corrugations in the zinc. The sheets are then secured to the rafters with round-headed

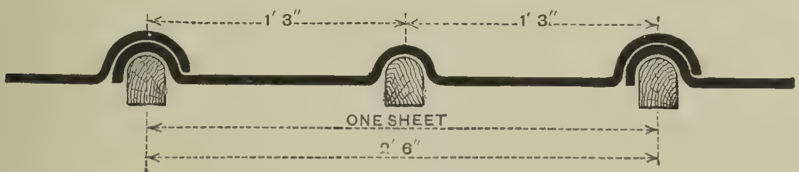

Fig. 201.—"Italian" Corrugated Zinc Roofing

screws, which fit down upon a raised socket and make a water-tight joint. The rafters measure about 3 in. by $1\frac{3}{4}$ in., and are supported by purlins fixed about 10 ft. apart.

This class of roof is very largely used for railway-stations, goods-sheds, warehouses, &c., and is a very economical and suitable covering for this class of building,

**Ornamental Zinc work.**—Zinc is also very largely used in the form of tiles, which are stamped in the same manner as that described for copper.

Fig. 202 shows a square dome in Tottenham Court Road, London, covered with zinc tiles by Messrs. Ewart & Son, Ltd., and very similar

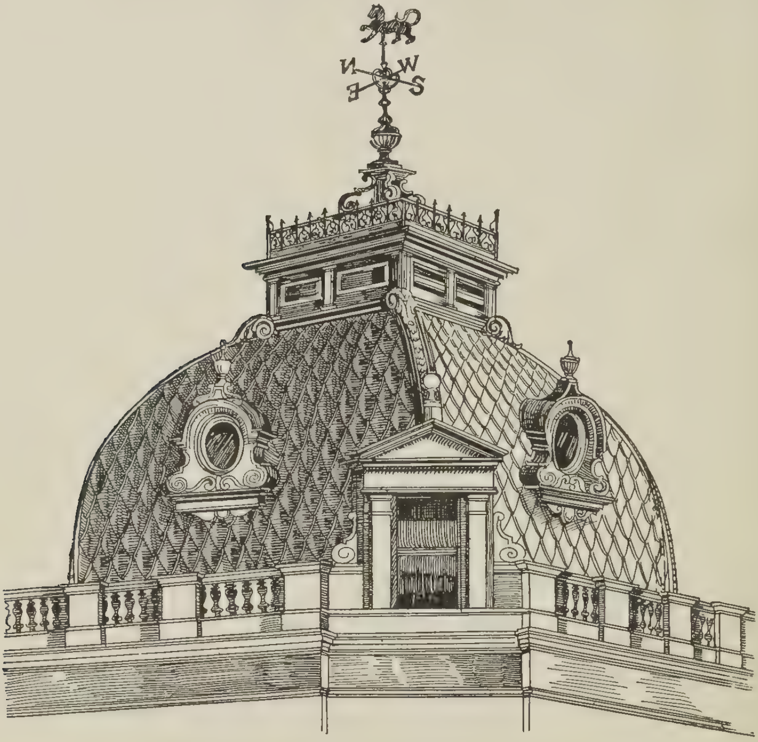


Fig. 202.—Roof covered with Stamped Zinc Tiles

work by Messrs. F. Braby & Co. may be seen on the Grand Hotel at Charing Cross.

# CHAPTER IV

## CORRUGATED-IRON ROOFING

**Sizes of Sheets.**—Corrugated iron is an inexpensive roofing material, largely used for temporary buildings. It is most frequently supplied in sheets 2 ft. 3 in. wide by 6 ft. long, with 8 channels and 9 ridges in each sheet, the corrugations measuring 3 in. from centre to centre, so that when lapped the sheet covers a width of 2 ft. net. Larger sheets are sometimes used, up to 10 ft. by 3 ft., with corrugations up to 5 in. The thickness of the sheets varies between No. 26 and No. 16 B.W.G., and they are generally galvanized, but are sometimes fixed in the black iron and painted. The galvanized sheets are better, if a good brand is obtained, with a

good deposit of zinc, and if these are used care should be taken that all bolts, washers, screws, &c., used in fixing are also galvanized.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| A 6 ft. by | 2 ft. | 3 in. | galvanized sheet | in | No. 26 | B.W.G. | weighs | 12 lb. |
| ,, | ,, | ,, | ,, | ,, | No. 24 | ,, | ,, | 16 ,, |
| ,, | ,, | ,, | ,, | ,, | No. 22 | ,, | ,, | 20 ,, |
| ,, | ,, | ,, | ,, | ,, | No. 20 | ,, | ,, | 24 ,, |
| ,, | ,, | ,, | ,, | ,, | No. 18 | ,, | ,, | 31 ,, |
| ,, | ,, | ,, | ,, | ,, | No. 16 | ,, | ,, | 40 ,, |

No. 20 B.W.G. is a good medium weight, and costs about 3*s.* for a 6 ft. by 2 ft. 3 in. sheet. This gauge requires supporting only at about 6 ft. to 8 ft. intervals.

**Methods of Fixing Sheets.**—The sheets are generally fixed with the corrugations running parallel to the slope of the roof, and are overlapped from 2 in. to 4 in. at the horizontal joints. They should be laid with the outer edges of the corrugations downwards, and should be fixed with galvanized screws or bolts through the ridges of the corrugations, galvanized washers being placed to form a better joint under the heads of the screws.

Fig. 203.—Braby's Corrugated Iron with Storm-proof Overlaps

A defect that sometimes occurs in corrugated-iron roofing is that in a heavy rain the water overflows at the laps, and in some specifications a lap of two corrugations instead of one is provided for. This, however, adds considerably to the cost of the roof, and does not always prevent the overflow. A better plan is to use sheets (supplied by Messrs. F. Braby & Co., Ltd.) with patent storm-proof overlaps (fig. 203), in which the outside corrugations are raised above the others, thus preventing the entrance of water at the laps even in the heaviest downpour.

Fig. 204.—Sheet-iron with Horizontal Corrugations

Corrugated iron is also sometimes laid with the corrugations across the slope of the roof. The sheets then cover the intervals between the principals, and no purlins are required. When fixed in this way, the ordinary corrugations will not, of course, throw off the water, and the sheets are corrugated with an angular flute resembling weather-boarding, as shown in fig. 204.

A greater fall is, of course, required, when the sheets are fixed in this way, than is necessary when the flutes are parallel with the slope. The cost of these sheets is the same as those with the ordinary corrugations, but they have an advantage in covering capacity on account of the smaller laps.

A third method of fixing corrugated iron is without wood supports, the sheets being bolted together and bent into a semicircular or segmental shape. This method is largely adopted for covering stables, farm-buildings, &c.

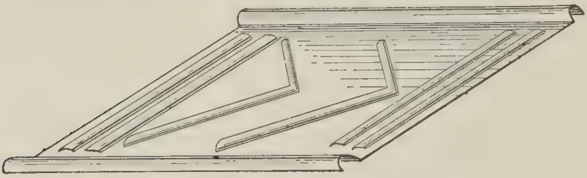

Fig. 205.—Stamped Galvanized-iron Tile

For this class of work galvanized iron is also used stamped into tiles of large size (about 3 ft. by 1 ft. 9 in.), with a single flute at each edge for lapping, and generally made in 24 B.W.G. (fig. 205).

# CHAPTER V

## MISCELLANEOUS WORK—BATHS, SINKS, AND VENTILATORS

**Copper Baths.**—Copper has been very largely used in the past for hooded spray- and shower-baths, as well as for ordinary plunge-baths, and is still so used to some extent. The metal is well suited to this purpose, as it is an excellent conductor of heat, and, its substance being thin (23 gauge), it is readily heated without an extravagant use of hot water. The copper sheets should be tinned and planished before being made up. The inside of the bath is then metallic-enamelled three or four coats, and stoved after each coat to a temperature of 200° Fahr., and afterwards hand-polished; a beautifully smooth surface is thus obtained. Copper baths are usually made with flanged edges (fig. 206), and are fixed on wood cradles and cased in mahogany or other hardwood, with panelled front and framed top, which should be $1\frac{1}{4}$ in. thick, and screwed to the casing with brass screws and cups.

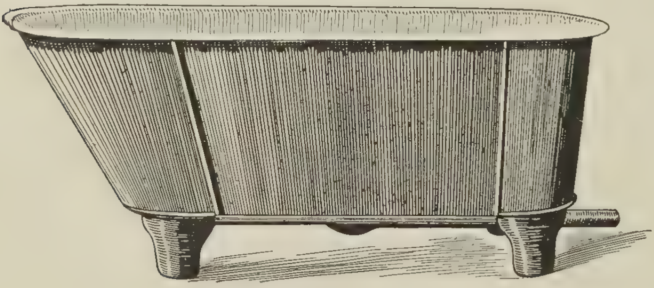

Fig. 206.—Copper Bath with Flanged Rim for Fixing in Wood Casing

A bath finished in this way has a very handsome appearance, but of late years it has given way to the cast-iron porcelain-enamelled independent bath, which is fitted with iron feet and stands without casing. It must be admitted that this arrangement is much more sanitary, the space behind the casing of the copper bath often being found to be in a very dirty condition. The porcelain enamel is also very much more durable than the

metallic, and will last for many years, while the copper bath will require removing and re-enamelling almost every year to keep it in good condition.

Copper is still, however, very largely used for portable hospital-baths, which are mounted on wheels, and fitted with a large gun-metal cock for drawing off the waste water (fig. 207). The wear and tear on a bath of this description is very heavy, and copper is the only suitable material, zinc not being sufficiently rigid, and cast-iron being too heavy to be easily portable. The copper is usually tinned and planished.

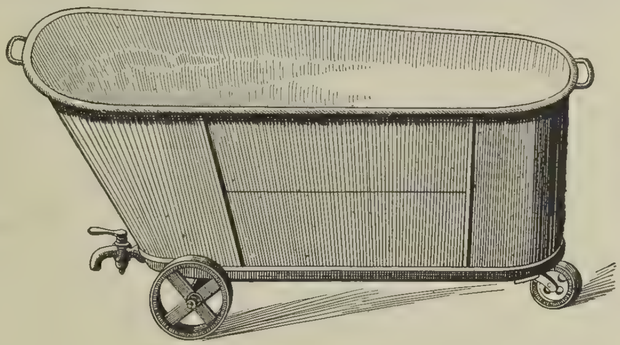

Fig. 207.—Copper Hospital-bath on Wheels

**Tinned and Planished Copper.**—The process of tinning is first to clean the sheets and then heat them over a coke fire and apply the tin with a flux of sal-ammoniac, wiping the superfluous metal forward until the sheet is covered. This process occupies some time, and it is questionable whether, in spite of the extra amount of tin required, it is not cheaper to pass the sheets through a bath, thus coating both sides of the metal.

The operation of planishing follows the tinning, the metal being well hammered all over the surface with a planishing hammer, the effect of which is to incorporate the tin with the grain of the copper. The tin coating naturally lasts very much longer when beaten into the metal in this way. The planishing hammer should be kept very clean and bright, and the blows applied uniformly all over the surface, so that a beautifully bright and even surface is obtained.

**Zinc Baths.**—Zinc is now very rarely used for baths, as the metal is so liable to buckle with the weight; where a sheet-metal bath is required, at a less cost than that of planished copper, galvanized iron or steel is generally used. Zinc, however, is largely used for making spray hoods for fitting over cast-iron independent baths, and, as the hood receives very little wear, the metal answers well for this purpose, and is cheaper than a copper hood.

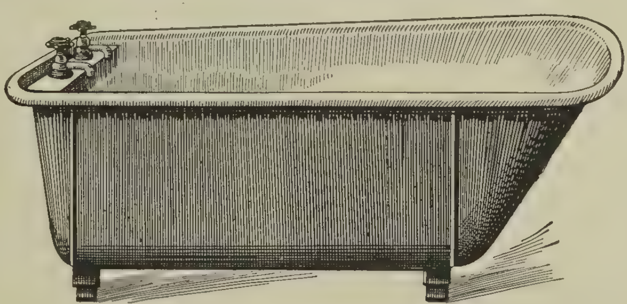

Fig. 208.—Stamped Steel Bath

**Stamped Steel Baths.**—Steel is largely used for the manufacture of baths, especially for foreign trade. The baths are stamped in sections and seamed together, as shown in fig. 208. The metal is tinned, and the feet are detachable for convenience in packing. The baths are made to "nest" one

inside the other for the same purpose, and are fitted with taps and plug-waste, and weigh about 56 lb. each. Six baths are packed in a case measuring about 7 ft. × 3 ft. × 3 ft., and the gross weight is about 6 cwt. Messrs. J. Tylor & Sons now make steel baths which are stamped in one piece and porcelain-enamelled on both sides.

**Sinks.**—Copper is very largely used for lining wood sinks, and does not buckle and crack as lead does when used for the same purpose. It has also a cleaner appearance, and as the surface is quite smooth, grease does not readily adhere to it. The copper sheets should be tinned and planished. The tinned and planished sheets are cut to fit into the wood casing, and are lapped at the angles with about 1 in. laps, which are then soldered. The sheets are secured around the upper edges of the sink with brass screws, counter-sunk into the metal.

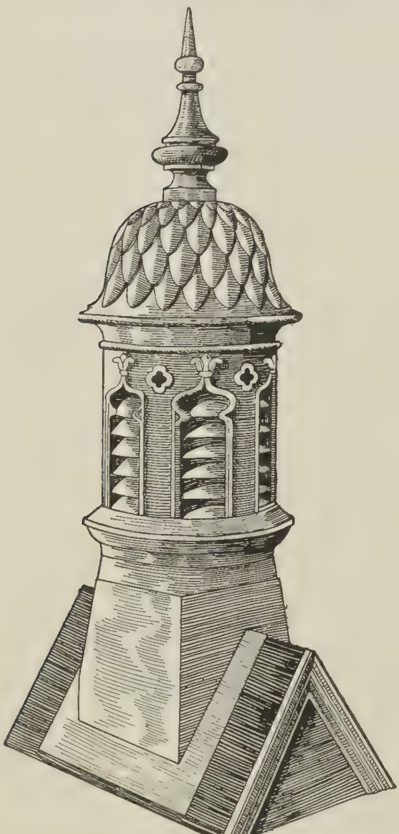

Fig. 209.—Ornamental Copper Ventilator

**Ventilators.**—These should always be made of copper, as, on account of the exposed position they occupy, any other metal quickly perishes. They are also made in zinc and in galvanized iron japanned, but the amount saved in the initial cost by using these inferior metals is quickly lost in renewals.

Ventilators are divided roughly into two classes—those with revolving heads and those with fixed parts. The objection to a ventilator with revolving head is that, although a reservoir is provided, which is filled with oil when the ventilator is fixed, and in which the spindle turns, this oil becomes dried up after a few years, and there is then the necessity of recharging, which, if neglected, causes the ventilator to creak in revolving, or to become set.

The comparative cost of such a ventilator in copper, with pipe 12 in. in diameter, and head 17 in. in diameter, is about £3, 10*s.*, as against about £2 for either zinc or galvanized iron japanned. These ventilators are sometimes made in galvanized iron japanned, but with copper fans, the fans being the first part to perish in an iron ventilator. The cost of a ventilator of this description is about midway between that of copper and zinc.

Fig. 209 is an illustration of an ordinary fixed ventilator of an ornamental type, made of copper, the dome being formed with stamped tiles of the kind already described.

# Section V—WATER SUPPLY

BY

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# SECTION V—WATER SUPPLY

## CHAPTER I

### WATER

**Pure water** is composed of two volumes of hydrogen and one of oxygen ($H_2O$); but as water is one of the greatest solvents in nature it is impossible to obtain it for consumption in this state of absolute purity, except by a process of distillation. Rainwater may be said to be distilled water, but it absorbs gases and dissolves salts from the atmosphere and earth.

"Pure water" is usually understood to be "water which contains nothing prejudicial to health, in case of potable or drinking water, or nothing to destroy the success of a technical operation when intended for industrial purposes".

**Rainfall.**—The source of our water supply is the rainfall, either in the form of rain, snow, or dew. The amount of this rainfall varies considerably in different parts of the world, and even in various districts of the United Kingdom. The amount for any particular locality can be ascertained by means of rain gauges, but to be reliable the observations should extend over a series of years to arrive at an average. Average rainfall years seldom occur, and provision should be made for exceptionally dry years, and perhaps several consecutively.

In that valuable annual, *British Rainfall*, the results of careful observations taken at about 3500 stations in this country are recorded.

In the issue for 1883, Mr. G. J. Symons sums up the following conclusions, at which he had arrived as the most probable fluctuations from the mean for any station situated in England:—

1. The wettest year will have a rainfall nearly half as much again as the mean.
2. The driest year will have one-third less than the mean.
3. The driest two consecutive years will each have one-fourth less than the mean.
4. The driest three consecutive years will each have one-fifth less than the mean.

The official figures for the rainfall in the London district stand thus[1]:—

| | 1906 | Mean 35 years |
|---|---|---|
| January, ...... | 3·49 in. ...... | 2·01 in. |
| February, ...... | 1·68 „ ...... | 1·69 „ |
| March, ...... | ·87 „ ...... | 1·49 „ |
| April, ...... | ·85 „ ...... | 1·65 „ |
| May, ...... | 1·19 „ ...... | 1·69 „ |
| June, ...... | 2·71 „ ...... | 2·01 „ |
| July, ...... | ·67 „ ...... | 2·27 „ |
| August, ...... | ·82 „ ...... | 2·30 „ |
| September, ...... | 1·65 „ ...... | 2·21 „ |
| October, ...... | 2·86 „ ...... | 2·70 „ |
| November, ...... | 3·73 „ ...... | 2·29 „ |
| December, ...... | 1·90 „ ...... | 2·15 „ |

The annual rainfall in England ranges from 177 in. at Stye Head Pass, in the Lake District, to about 21 in. in the district S.S.W. of the Wash. The remaining portions of England have an average annual rainfall of about 30 in., that for the whole of England and Wales being probably between 33 and 34 in. per annum.

Generally speaking, about one-third of the rainfall is absorbed by the ground on which it falls, being utilized for the support of vegetable life, and the feeding of wells, springs, &c. About one-third is evaporated to fall again as rain, and the remaining third flows off to form streams, lakes, and rivers, which, augmented by the overflowing springs, ultimately flow into the sea to join again in the cycle of evaporation and rainfall.

These proportions vary considerably, however, according to the temperature and to the nature of the catchment area. If the latter is covered with vegetation, the soil being of a gravelly or porous nature and fairly level, more water will be absorbed than when the surfaces are steeply sloping or of an impervious nature.

**Classification.**—The Rivers Pollution Commissioners have summarized the characteristics of water from various sources as under:—

| | | |
|---|---|---|
| Wholesome. | 1. Spring.<br>2. Deep-well water. | Very palatable. |
| | 3. Upland surface water. | Moderately palatable. |
| Suspicious. | 4. Stored rainwater. | |
| | 5. Surface water from cultivated land. | Palatable. |
| Dangerous. | 6. River water to which sewage gains access.<br>7. Shallow-well water. | |

The Commissioners arrange the different kinds of water in ascending order of hardness, as follows:—

1. Rainwater.
2. Upland surface water.
3. Surface water from cultivated land.
4. Polluted river water.
5. Spring water.
6. Deep-well water.
7. Shallow-well water.

[1] Published in *The Daily Telegraph*, 8th January, 1907.

**Analysis of Water.**—When there are any doubts as to the purity of a water, a sample should be submitted for analysis by an expert. Care should be taken that an average sample is obtained. In the case of water from a stream it should be taken from near the centre instead of from near the banks; if from wells, the pumps should be kept going for a short time to clear out the water which may have been standing in the barrels and pipes; and when from a town supply, it should, if possible, be drawn direct from the main. If drawn from a house tap, the latter should be left running to waste for a short time before the sample is taken, so as to empty the pipes of the water which may have been standing in them.

A glass-stoppered "Winchester quart" bottle, which contains rather over half a gallon, is most suitable for the purpose. It should be well washed out first with a little acid, and then thoroughly rinsed with the water to be collected. The glass stopper should be covered with a piece of clean calico, wash leather, or gutta-percha tissue, tied down, and sealed with sealing wax. If a suitable glass stopper is not available, a clean new cork should be used and capped as described. A label should also be attached, giving particulars as to the date of collection, source of supply (whether from wells, streams, &c.), and the possible cause of pollution, if suspected; also the nature of the pipes in which the water is conveyed, and any other information which may be considered necessary.

The sample should be kept in a cool dark place until tested, and if it is believed that there are organic impurities present, the analysis ought to take place within forty-eight hours after collection.

Authorities differ as to the desirability of giving any information when submitting a sample of water for analysis, some maintaining that it may unduly influence the analyst in making his report. Others hold that in cases where the condemnation of the water as a source of supply is involved, the more information which can be furnished the better.

Chemical analysis alone may at times be insufficient to determine whether a water is or is not fit for domestic use. It may show a water to be chemically pure which is proved by a bacteriological examination to contain disease germs. Again, a water may be bacterially pure which from a chemical point of view is suspicious. The final verdict as to the purity or otherwise of a water should therefore rest with the chemist and the bacteriologist in collaboration, the former affording a guide as to the general character of the water, and the latter giving information as to the nature and number of micro-organisms present.

**Impurities.**—Many inorganic impurities present in water have little or no influence on health.

Organic matter of animal origin is usually the most dangerous. The ratio of *nitrogen* to *carbon* is important—animal matter contains more nitrogen in proportion to carbon than vegetable matter; hence a sample giving a high proportion of nitrogen should be looked on with suspicion. The Rivers Pollution Commissioners considered that a good drinking water should not contain more than ·2 part of organic carbon, and ·02 part of organic nitrogen per 100,000.

*Ammonia*, either free or albuminoid, is usually considered an indication of animal organic contamination, but it is removable by filtration.

*Nitrates* and *nitrites* indicate probable previous pollution, and when in conjunction with ammonia and chlorine indicate sewage contamination.

*Chlorine* indicates animal pollution, but is not an absolute proof of sewage contamination, unless in districts distant from the sea or where there are no natural deposits of salt. It is more or less harmless and is not removed by filtration.

**Physical Properties.**—A good water for domestic purposes should be colourless and clear, free from sediment or turbidity, of sparkling taste, inodorous and moderately hard.

Its **colour** can be judged by looking through a good depth of it, say in a glass jar 18 in. or 2 ft. deep, with a white background. The purest waters have a bluish tint; a greenish tint may be due to vegetable matter, and a yellowish one to animal matter or salts of iron. Peat sometimes causes a brown or yellow tint, and minute living organisms frequently impart colour.

**Clearness** indicates that the water is free from solid matters causing turbidity, but is no guarantee that the water is free from pollution. If there is much solid matter in suspension it should be allowed to stand for a few days, so that sedimentation can take place, when, by the aid of a microscope, the nature of the sediment can be determined. Some of this may be dangerous, but the presence of certain organisms does not prove that the water is bad, neither does it follow that because a water is clear and sparkling it is free from disease germs.

The **taste** of good drinking water should be pleasant, due to the presence of atmospheric air and carbonic acid, without which it would be "flat" and insipid. Iron can be tasted, but organic matter may be present in dangerous amounts without being detected by the palate. Saline salts in small quantities may also be undetected. Generally, if anything other than atmospheric air and carbonic acid can be tasted in water, it ought to be regarded with suspicion.

**Odour.**—Pure water is inodorous, except in certain cases where, when it is freshly drawn, there is a slight odour of ozone. The odour from impure water may be due to the products of decomposition of organic matters, chiefly ammonia, hydrogen sulphide, and ammonium sulphides. If such water is warmed in a flask up to about 80° F., the smells are found to be more pronounced.

**Soft and Hard Water.**—The terms *soft* and *hard*, when applied to water, are relative only, and connote the absence or presence of certain salts which affect the ease with which a lather can be formed with soap. With hard water it is difficult to produce a lather, whereas with soft water it is difficult to wash the soap off the hands.

Pure rainwater is very soft, but by absorbing gases, and dissolving certain salts as it flows over the surface or percolates through the ground, it soon becomes harder. The dissolved salts which cause this hardness are chiefly the carbonates and sulphates of lime and magnesia, and occasionally the chlorides and nitrates. Iron may also be present. Some of these salts,

such as the carbonates, can be precipitated by boiling, but others, such as the sulphates, cannot be removed in this way. Hence the terms *temporary* and *permanent hardness.*

The amount of hardness is usually estimated in degrees on Dr. Clarke's scale, each degree corresponding to 1 grain of chalk dissolved in 1 gallon (70,000 grains) of water. Dr. Clarke's test consists in employing a solution of soap of known strength, and ascertaining how much of this solution is required to form a lather which will last a certain time.

Within moderate limits—that is, up to about 16° or 17°—the hardness of water does not appear to be prejudicial to health, except in some peculiar diseases such as calculus; but it cannot be used for many manufacturing purposes, unless softened; and the sediment thrown down by its use in boilers, &c., is very injurious owing to the scale deposited. Soft water is absolutely necessary for certain manufactures, such as bleaching, dyeing, calico-printing, and wool-washing, also in all cases where soap is extensively used. It is also useful when required for heating purposes, as it obviates "furring". Hard water is requisite for ale-brewing.

**Action of Water on Metals.**—Pure water is the greatest solvent in nature, and acts more or less on a number of the metals, thereby becoming contaminated.

Lead is particularly affected by rainwater and water from moorland peaty districts, both kinds being soft and comparatively pure. As the metal is poisonous, such waters ought not to be stored in lead-lined cisterns, or passed through long lengths of lead piping. As little as $\frac{1}{20}$th of a grain of lead dissolved in a gallon of water may be considered dangerous, and water containing even a smaller proportion will, if imbibed for a sufficient length of time, cause symptoms of lead-poisoning.

The action of water on lead appears to depend on the amount of oxygen and carbonic acid present in the water. If there is a large quantity of oxygen the lead is rapidly oxidized, and the oxide of lead is to a certain extent soluble; but if the water contains a sufficient quantity of carbonic acid to convert the oxide into carbonate of lead, which is only slightly soluble, the water will be comparatively safe from dangerous contamination.

The action of moorland water on lead is chiefly due to the small amount of organic acids dissolved by the water from the peat. When required for domestic purposes every effort should be made to get the water off the peaty gathering-grounds as quickly as possible, and as much time as practicable should be given for subsidence and bleaching. It should then be allowed to flow over calcium carbonate, which will increase its hardness to about 2½ degrees.

Similar waters also act on zinc, dissolving sufficient to cause certain obscure maladies when the water is used for dietetic purposes. Zinc-contaminated water will show an indistinct "greasy" film on its surface. Such waters affect not only sheet zinc but also the zinc "galvanizing" coating applied as a preservative to wrought-iron pipes and cisterns.

Hard water forms an insoluble protecting coat, chiefly of sulphate of lime, on lead surfaces.

Pure water acts rapidly on unprotected iron and steel pipes, cast iron being less affected than wrought iron, and wrought iron less than steel. Cast-iron pipes can be protected by various processes, such as Dr. Angus Smith's, the Bower-Barff, and glass-enamelling. Wrought-iron pipes may be galvanized, or coated with an asphaltum mixture, and steel pipes may first be galvanized like wrought iron, and then coated with natural asphal tum, or with a specially prepared composition of pitch, tar, petroleum, linseed oil, and chalk.

**Boiling Water.**—Water boils at a temperature of 212° F., or 100° C., under ordinary atmospheric pressure at sea level.

Boiling is a safe and simple method of treating water of doubtful quality when to be used for domestic purposes. During the process of boiling, carbonic acid ($CO_2$) is driven off, and certain salts are precipitated, taking down with them other matters in suspension, and at the same time destroying many disease germs which may be present. It has been found, however, that a temperature of 212° F. is not sufficient to kill all the disease germs and their spores, the spores being more resistant than the microbes themselves.

**Distillation** is a safer but more expensive process. Distilled water is condensed water vapour, and, although perfectly pure, is very unpalatable, having lost its oxygen and carbonic acid, and the lime and magnesia salts previously held in solution.

The "flatness" of boiled or condensed water is a great drawback when the water is to be used for dietetic purposes, although some of its original properties can be restored by a system of aeration, &c. Moreover, boiled and distilled water will not keep "sweet" for more than twenty-four hours.

When absolute immunity from all danger of using polluted water is required, **sterilization** is resorted to. The water is raised to a temperature of over 212° F. in a closed vessel, which prevents ebullition and consequent production of steam, and this temperature is maintained long enough to destroy all disease germs and their spores. There is no appreciable loss of oxygen or carbonic acid, the water retaining its original crisp and pleasant taste.

Raising the temperature of the water usually has the effect of increasing its solvent powers, although sulphate of lime is less soluble in hot than in cold water, and common salt dissolves to the same extent whatever the temperature. Water expands about $\frac{1}{25}$th of its bulk when heated from 39·2° F. (its point of greatest density) to 212° F., so that 25 gal. of cold water are nearly equal to 26 gal. at boiling-point.

**Pressure and Head of Water.**—The pressure of water is proportional to its depth, and is generally stated as being equal to $\frac{1}{2}$ lb. on every square inch of surface, for every foot in depth, the actual pressure being ·433 lb. The weight of water is in proportion to its bulk or quantity, but the pressure depends on its vertical height only.

The **head of pressure**, or simply the **head**, at any point, is the vertical distance of that point below the surface of the water, and is generally expressed in feet.

A column of water 1 ft. high = ·433 lb. pressure per square inch.
Head of water in feet × ·433 = pressure in lb. per square inch.
„ „ × 62·4 = „ „ „ foot.
Total surface (in sq. ft.) of a closed vessel × head of water in feet × 62·4 = total pressure in lb.
„ „ (in sq. in.) × head of water in feet × ·433 = total pressure in lb.
„ „ (in sq. ft) of an open vessel × half depth in feet × 62·4 = total pressure in lb.

A cubic foot of water weighs about 62·4 lb.

Cubical contents (in feet) of a vessel × 62·4 = weight in lb. of contained water.

WEIGHT AND VOLUME OF WATER

| | British Standard Temp. 62° F. | Freezing-point. 32° F. | Boiling-point. 212° F. |
|---|---|---|---|
| 1 cu. in. of pure water weighs ... | ·03606 lb. | ·03612 lb. | ·03458 lb. |
| 1 cu. ft. „ „ ... | 62·321 „ | 62·418 „ | 59·76 „ |
| 1 lb. (7000 grains) of pure water measures ... ... ... | 27·727 cu. in. | 27·684 cu. in. | 28·978 cu. in. |
| 1 imperial gallon contains ... | 277·274 „ | 276·84 „ | 289·78 „ |

| | | | | |
|---|---|---|---|---|
| 1 imperial gallon | = 10 lb. | = 277·274 | cu. in. | = ·16 cu. ft. |
| 1 cu. ft. | = 62·32 lb. | = 6·232 | imperial gallons (or nearly $6\frac{1}{4}$). | |
| 1 cu. in. | = ·03606 lb. | = ·003606 | imperial gallon. | |

Imperial gallons × ·16 = cubic feet.
„ ÷ 6·23 = „

| | PURE WATER | | SALT WATER | |
|---|---|---|---|---|
| 1 ton. | = 224 gal. | = 35·84 cu. ft. | 217·95 gal. | = 35 cu. ft. |
| 1 cwt. | = 11·2 „ | = 1·792 „ | 10·897 „ | = 1·75 „ |

1 cu. ft. of ice at 32° F. = 57·96 lb.

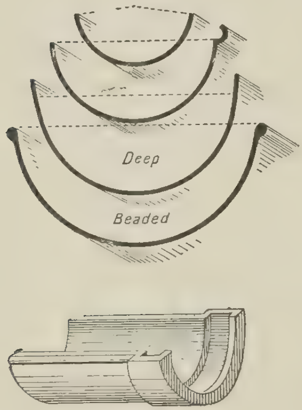
# CHAPTER II

## RAINWATER COLLECTION AND STORAGE

### *GUTTERS AND PIPES*

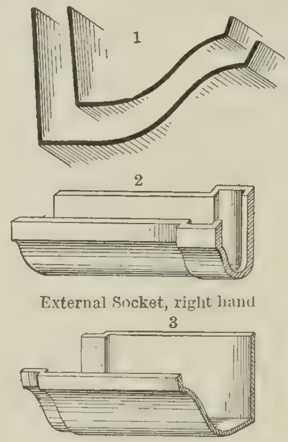
**Eaves Gutters.**—The rainwater which falls on the roofs of buildings is usually collected in channels fixed under the overhanging eaves, and conducted at convenient intervals by pipes leading to the ground. These channels are termed *eaves gutters*, *spouting*, or *troughs*, and in Scotland *rhones*; the pipes are usually termed *rainwater pipes*, *down pipes*, *stack pipes*, or *conductors*. They are generally made of cast iron, and their size and pattern will vary according to the area and nature of the roof which they serve.

The gutters vary in section; fig. 210 shows four varieties of the simple semicircular or "half-round"; fig. 211, the ogee moulded; and fig. 212, one of the more ornamental patterns. The standard length is 6 ft., but short or



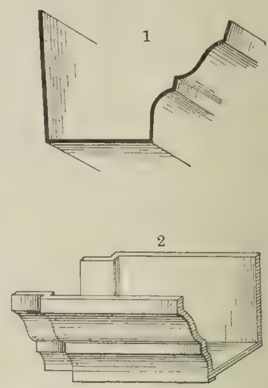

External Socket, right hand

Fig. 210.—Semicircular Eaves Gutters




Internal Socket, left hand

Fig. 211.—Ogee Eaves Gutters




Internal Socket, left hand

Fig. 212.—Moulded Gutters

"making-up" pieces are also made, in lengths of 2, 3, and 4 ft. Short nozzle pieces or outlets are also supplied for fixing over the down pipes, and stopped or close ends, plain or moulded, for finishing the ends (fig. 213). Angle pieces are made either for internal or external angles, and suitable for right angles or any other change of direction (No. 2, fig. 213). The stopped ends and angle pieces are made either right- or left-handed.

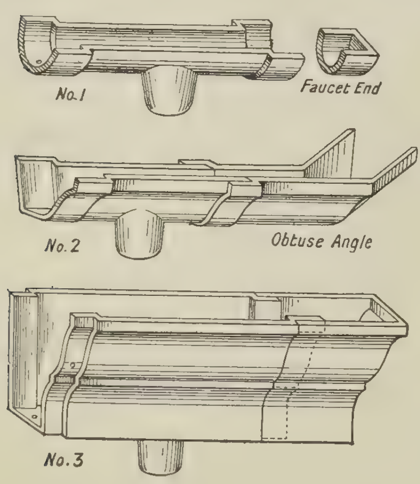



Fig. 213.—Nozzle Pieces, Obtuse Angle, and Stopped Ends

No. 1, Half-round nozzle piece; No. 2, ogee nozzle piece; No. 3, moulded nozzle piece and stopped end.

**Half-round Gutters** (fig. 210) are obtainable from 3 in. to 6 in. in diameter, increasing by half-inches, and some manufacturers supply gutters measuring 7, 8, and 9 in. in diameter. They are usually made in three different thicknesses, known as "light", "medium", and "heavy", and are generally described as weighing "so many lb. per foot run", or per 6-ft. length. The thickness of metal in the light quality is $\frac{1}{8}$ in., in the medium $\frac{3}{16}$ in., and in the heavy $\frac{1}{4}$ in. The usual sizes are those measuring 3, 4, 5, and 6 in. in diameter; their weights (for the light section) averaging 9 lb., 13 lb., $16\frac{1}{2}$ lb., and 23 lb. respectively per 6-ft. length.

**Brackets.**—These gutters are supported on wrought-iron hooks or brackets (fig. 214), which may be about $1\frac{1}{4}$ in. or $1\frac{1}{2}$ in. broad, and $\frac{1}{4}$ in.

thick, shaped at one end to receive the gutter, and holed at the other end for screwing or nailing to the rafters or other support. Nos. 1, 2, and 3 are for fixing to the rafters or roof boarding, No. 2 being twisted so that it can be fixed to the side of the rafter; Nos. 4 and 5 are for fixing to the fascia or wall; and No. 6 for fixing to the wall, A being a wrought-iron spike for driving into a joint, and B a cast-iron bracket screwed to the spike. Many other varieties of bracket are also made.

**Fixing Half-round Gutters.**—As these gutters are very shallow, they are usually fixed with a slight fall or current towards the outlets, and this want of uniformity in a long length of guttering, alternately falling right and left, detracts somewhat from its appearance.

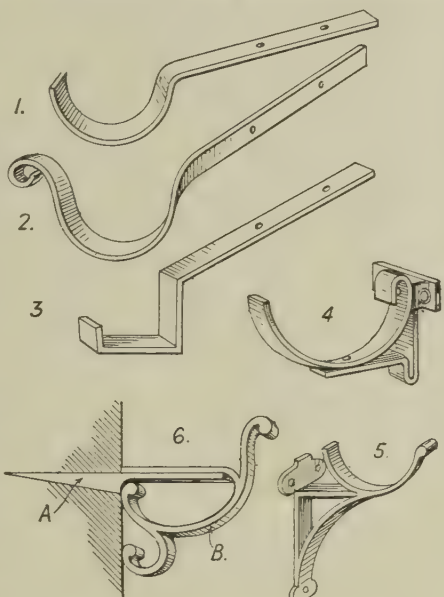


Fig. 214.—Brackets for supporting Gutters

In jointing the various lengths together, a layer of putty composed of linseed oil and red lead, or of linseed oil and equal parts of red and white lead, termed oil cement, is first spread in the socket or faucet of one length, on which is laid the plain or spigot end of the next length, and the two are firmly screwed together by the special bolt and nut provided for the purpose (fig. 215). On the efficient filling up of the space between the spigot and socket depends the soundness of the joint; for, if this is not carefully done, the result will be that whenever there is any water in the gutter, a constant drip will take place from every defective joint. Sufficient jointing material should be used to admit of the surplus being squeezed out as the bolt is tightened up.


Fig. 215.—Gutter Bolt and Nut

**To Prevent Displacement.**—Sometimes the guttering is merely laid into the hollows of the brackets, and is consequently easily displaced or revolved on its bed, either by the action of the wind, by ladders being roughly leant against it, or by an accumulation of snow, which, sliding down the roof in a mass, frequently carries the gutter with it, and perhaps some of the rainwater pipes as well. To guard against this, pieces of hoop iron are sometimes nailed at one end to the roof boarding, whilst the other is passed over the top of the gutter and turned down. Another and more satisfactory method is to bolt the gutter and bracket together, similar to the joints of the gutter itself, and further security is occasionally afforded by enclosing between the gutter and bracket a strip of zinc, long enough to be turned over the upper edges of the gutter after they are all bolted together.

**Moulded Gutters** can be obtained in a great variety of sections, from the

simple ogee to the most elaborate form. As they are deeper than the semicircular gutters, it is not so necessary to give them a fall towards the outlets; hence they are usually fixed level.

Gutters of the ogee section (fig. 211) have, as a rule, projecting or external sockets similar to the half-round variety; consequently each joint can be distinguished along the eaves, and they are frequently cast with lions' heads or other ornaments on the faucets, and occasionally also at intermediate points. Sometimes, however, internal sockets are provided on ogee gutters, and also on the more elaborately moulded gutters, as in No. 3, fig. 213, so that when fitted together they show an unbroken line, giving the appearance of a cornice. The screws which secure the adjoining lengths together are inserted from the under side, and as the holes are countersunk no projection is seen, the nuts being screwed up from the inner side. Before screwing up, the faucet should be well filled with oil cement as before.

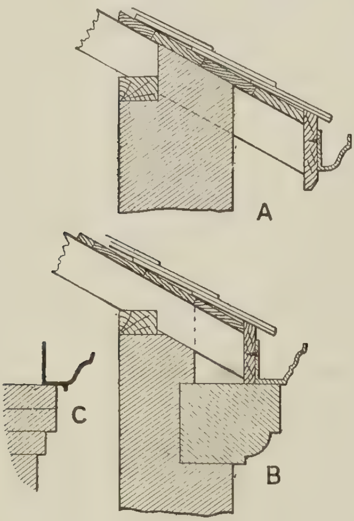



Fig. 216.—Gutters fixed with Screws to Wood Fascias, &c.

**Fixing Moulded Gutters.** — Moulded gutters are more easily fixed than those of a semicircular section, but care is necessary to ensure that the heavy varieties are properly supported. Where a fascia board is fixed to the ends of the rafters, the gutter may be secured to it by means of screws, which should be of a good strong pattern, as the whole weight of the gutter has to be supported by them (A, fig. 216). Where there are sailing or projecting courses of brick or stone along the eaves, it is usual to let the back edge of the gutter rest on the wall. This arrangement ensures the gutter being kept in alignment, besides reducing the risk of its breaking away (B and C, fig. 216).

The holes for the screws are countersunk, and in course of time the heads of the screws are liable to rust and break off. This is often brought about by the shocks to which the gutters are at times subjected, owing to ladders being leant against them, and also to the accumulations of snow which occasionally slide down the roof.

**Drip.**—A rib or fillet is sometimes cast on the soffits of moulded gutters to form a drip, which prevents the water from running down the walls (C, fig. 216).

**Angles, Stopped Ends, &c.**—Some of the most important details of gutters are given in fig. 217, but it is unnecessary to describe these seriatim. Attention may be drawn to the two forms of socket shown in Nos. 1–5 and Nos. 6–10, and to the union clips (Nos. 13 and 25) for connecting two plain ends of guttering.

**Cleansing and Painting.**—All gutters should be inspected and cleared out periodically, as sediment of various sorts collects in them, including dust, leaves, birds' droppings, pieces of broken slates and mortar, and sometimes

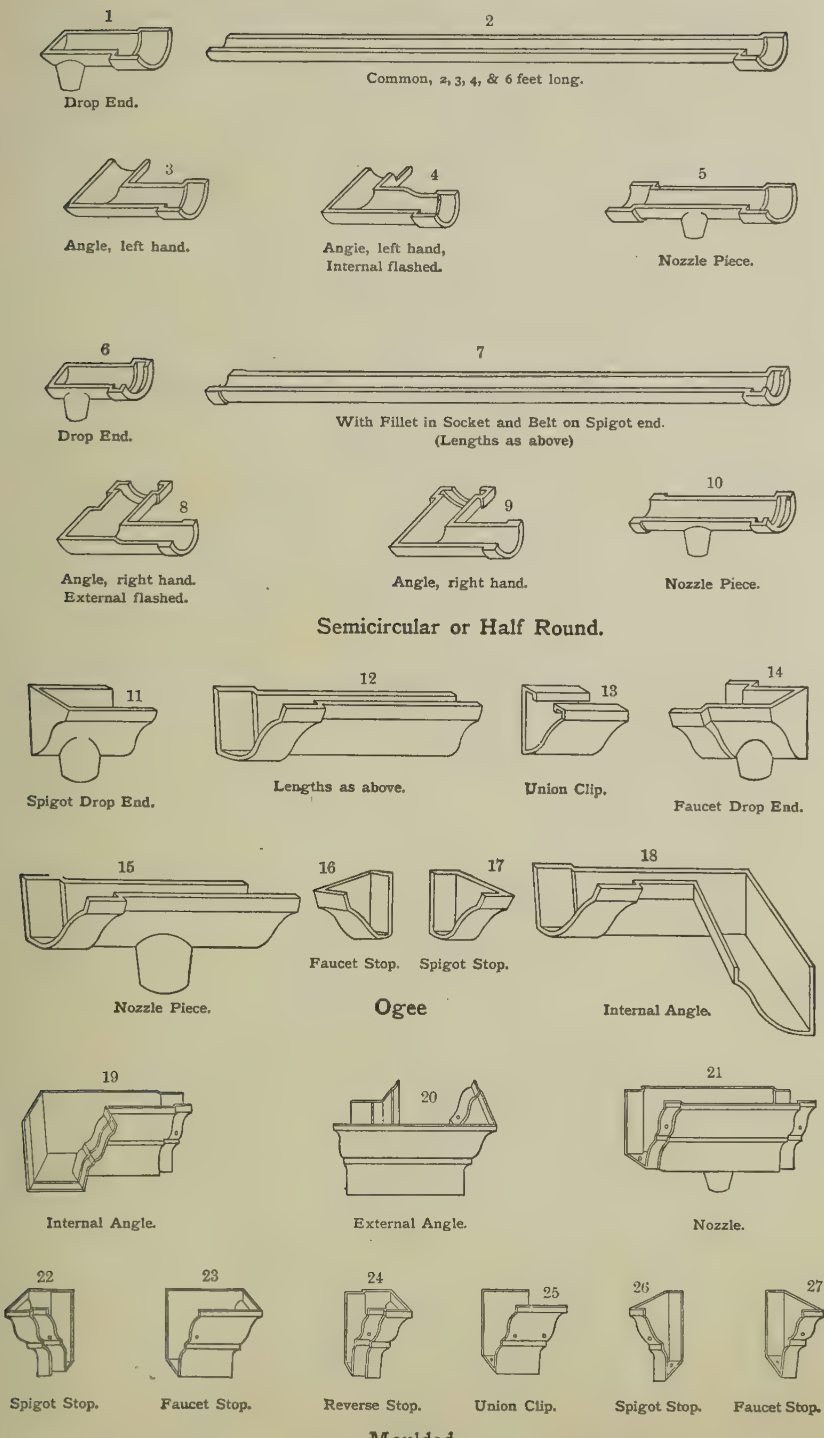



Fig. 217.—Eaves Gutters and Connections

birds' nests, and these all tend to check the flow of water to the outlets, and cause an overflow. The gratings over outlets should be taken out to see that the down pipes are clear, and where there are hopper heads, they too should be examined, and cleared if necessary. All fastenings should be examined, and joints restanched where required.

The backs or inaccessible portions of all gutters should be painted before being fixed. Gutters are supposed to have had at least one coat of paint at the foundry immediately after they are cast, but much of this gets removed during transit, and if the final coats are not applied until the fixing has been completed, the backs cannot be got at.

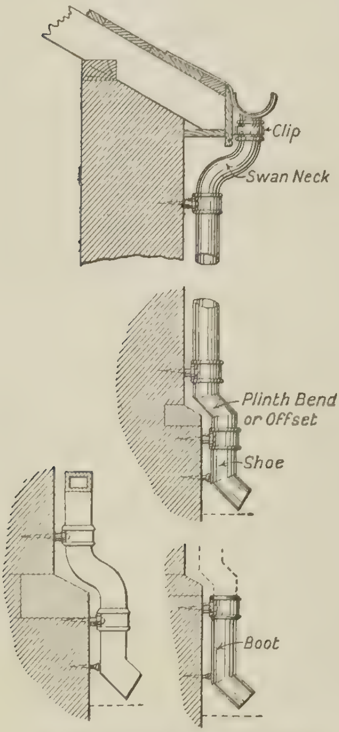


Fig 218.—Cast-iron Rainwater Pipes

The **down pipes** (fig. 218) may be either circular or rectangular in section, and are usually made in lengths of 6 ft. (although shorter lengths of 2, 3, and 4 ft. can be obtained), with a socket at one end to take the plain end of the adjoining pipe, and generally with lugs or ears cast on at the socket end to enable them to be fixed to the walls.

The top may be terminated by a hopper head, into which the gutter discharges its contents. When the eaves project some distance from the wall, a bend or *swan neck* is required to connect the nozzle outlet of the gutter with the pipe direct, as in fig. 218, or it may discharge into a hopper head fixed at the top of the down pipe.

*Offsets* or *plinth bends* (fig. 218) are required at such places as the plinths at the base of buildings, and *shoes* are used at the feet of the down pipes to shoot the water clear of the building, unless the pipes discharge into path pipes (fig. 228) or are connected directly to the surface-water drains (figs. 240–243).

**Fixing Pipes.**—In fixing these pipes they should be blocked out slightly from the wall. This enables leaky joints to be more readily repaired, and admits of the back of the pipe itself being scraped and painted when required. There is also less danger of the face of the wall being disfigured by the rusty stains caused through leaky joints. The pipes, as usually made, have the lugs or ears cast on in such a way that the pipes almost touch the wall when they are placed against it, but by introducing collars or thimbles of wrought-iron tubing about 1 in. or 1½ in. long at the back, as distance pieces, and driving the spikes through them, as shown in fig. 218, the pipes can be fixed at any desired distance.

The wrought-iron spikes or stack-pipe nails should be of sufficient length to ensure a good fixing to the wall, and may be 5 in., 6 in., or 7 in. in length, according to the projection and weight of pipe to be supported,

two being required at each joint. Nails with ornamental heads are sometimes used.

The sliding faucet (fig. 219), introduced by Messrs. Walter Macfarlane & Co., facilitates the renewal of a length of pipe without disturbing the adjoining lengths.

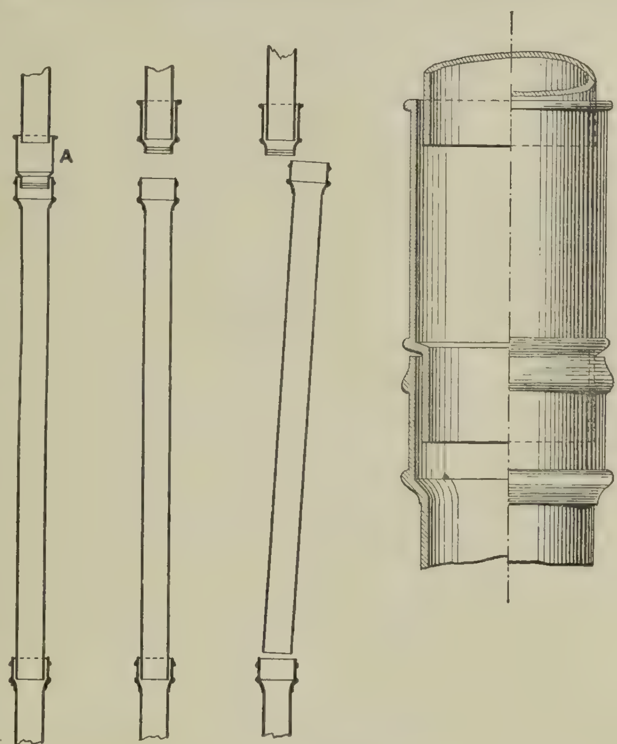



Fig. 219.—Macfarlane's Sliding Faucets

For fixing pipes cast without ears or lugs, special ear bands, which may be plain or ornamental, are employed. They are spiked to the wall and clasp the pipe between the beads of the faucet (fig. 220). Another method of fixing the uneared pipes clear of the walls is by means of projecting holder bats (fig. 221), which are either let in or built into the walls. Macfarlane's patent holder bats (fig. 222) have triangular lugs that slide into corresponding sockets formed in projections on the backs of the pipes. The pipes can be taken down and replaced without disturbing the holder bats or injuring the wall. Law's patent pipes are on somewhat similar lines, but the dove-tailed projection is cast on the back of the pipe, and fits into a corresponding groove in the support, which in this case is fixed to the wall with nails. The groove is lined with lead to prevent corrosion, and the support is of such a shape that the pipe stands about 2 in. away from the wall.

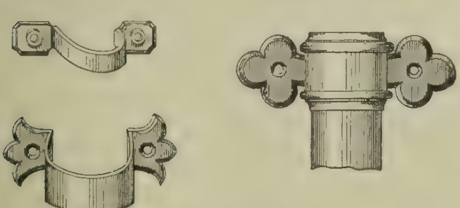


Fig. 220.—Ear Bands or Clips

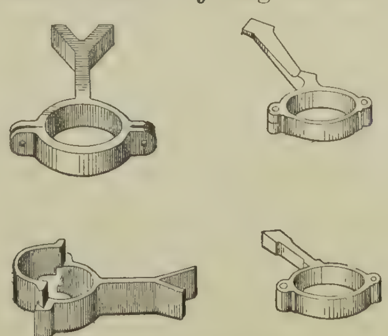


Fig. 221.—Projecting Holder Bats

In fixing the ordinary 6-ft. lengths of down pipe to a brick wall, by nails or spikes driven into the joints, it frequently happens that the holes in the ears do not coincide with the joints, either vertical or horizontal. Sometimes

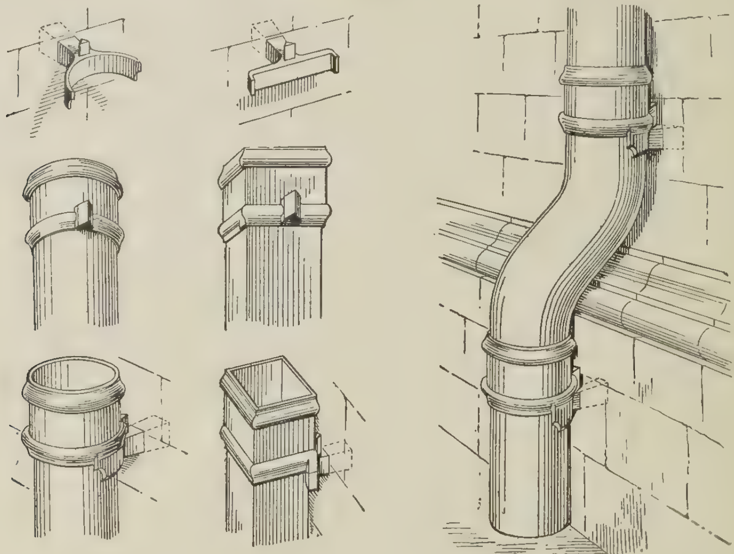
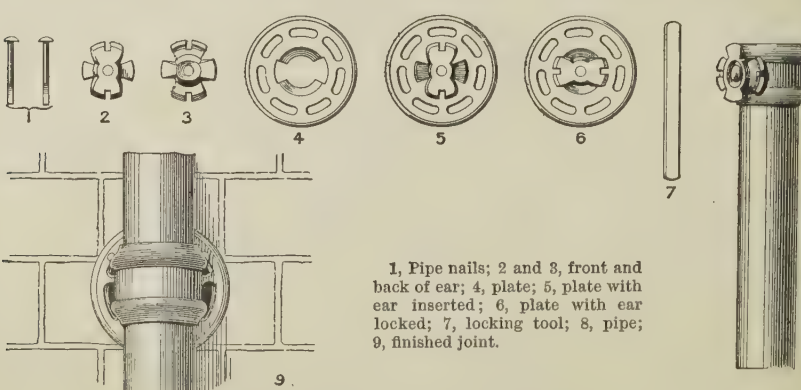



Fig. 222.—Macfarlane's Patent Holder Bats, &c

the workman may work them in by only inserting the spigot end of the pipe a little way into the adjoining socket, failing which he may have to cut a small piece off the pipe. Lockerbie's "Duecless" patent ear plate (fig. 223) obviates this difficulty, as the perforations in it are so arranged that




1, Pipe nails; 2 and 3, front and back of ear; 4, plate; 5, plate with ear inserted; 6, plate with ear locked; 7, locking tool; 8, pipe; 9, finished joint.

Fig. 223.—Lockerbie's "Duecless" Patent Ear Plate

two nails can always be driven into the joints, thus saving plugging the wall or the risk of cracking the brick. The arrangement has the further advantage of blocking out the pipes 1½ in. clear of the wall.

The pipes are fixed commencing at the foot and working upwards. If

there is a plinth to the building, an offset or plinth bend (fig. 218) must be fitted up temporarily in its proper position, and then the shoe. It will depend upon the height of the plinth above the ground whether a short piece of pipe will be required between the bend and the shoe. If the down-pipe is to discharge into a gully at its foot (fig. 239), the shoe can be kept well up, and out of the way of the grating. A spike should be driven into the wall for the lower end of the shoe to abut against (fig. 218); otherwise the leverage which can be exerted on the projecting portion of the shoe is liable to disturb the joint above, and will frequently be found to work the nails loose. Long shoes, termed "boots" (fig. 218), can be obtained, which may save cutting short lengths of piping when the ordinary shoe is too short. Law's anti-splash shoe is better than the usual shoe, as it breaks the force of the descending water and discharges it vertically.

**Jointing Pipes.**—In forming the joints the spigot end should be inserted full into the socket of the lower pipe, and so on until the top is reached. Sometimes, to save cutting a short piece, the workman will only place the spigot a short distance into the socket, thus saving an inch or so, but at the expense of an inferior joint. A few strands of tow should first be inserted in the joint and carefully forced home, to centre the pipes, before filling up the remainder of the joint with the oil cement. The tow also prevents the jointing material from escaping and dropping down the pipe. A careless workman will only place a little of the putty round the mouth of the joint, and this, owing to the expansion and contraction of the metal, soon cracks and drops down, allowing the spigot end to become loose, and, by vibration, affecting all the upper joints. A good way of testing some of these joints when newly formed is to pass a stiff piece of wire down through the stopping at intervals; moving the lower end of the pipe slightly before the stopping has got hard will also indicate whether the joint has been properly formed.

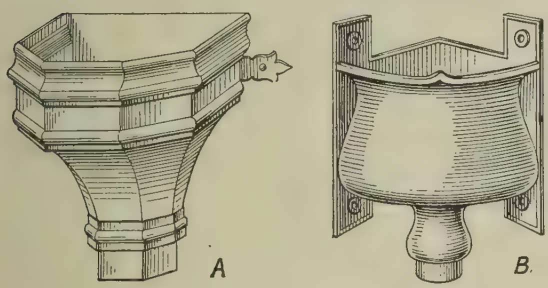



Fig. 224.—Cast-iron Hopper Heads. A, Flat; B, Angular.

**The top of the stack pipe** may be completed by a hopper head, which may be flat or angular, and of cast iron or lead (fig. 224), into which the gutter discharges, or if the gutter projects considerably from the face of the wall, a swan neck or offset may be introduced between the nozzle of the gutter and the top of the stack pipe (fig. 218). These swan necks can be obtained suitable for various projections, from 3 in. to 18 in. or more as required. The stack pipe should be fixed in line with the nozzle in the gutter, but sometimes when a swan neck of the exact dimensions is not available, one of a larger size is used and fixed askew, the stack pipe being moved either to the right or left to suit. Swan necks and bends are also used where a change of direction is required in a stack pipe. Other

fittings for rainwater pipes, collected in fig. 225, do not call for detailed description.

**Gratings.**—To prevent leaves, birds' nests, or other rubbish which may

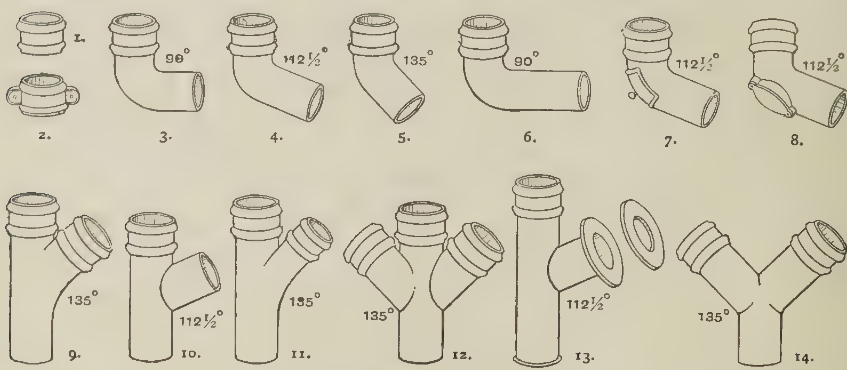



Fig. 225.—Fittings for Rainwater Pipes

1 and 2, Sockets; 3 to 6, bends; 7 and 8, access bends; 9 to 11, single junctions or branches; 12, double junction; 13, flanged junction; 14, Y junction.

collect in the gutters from being washed down into the stack pipes, and so tending to choke them, causing unsightly overflows, or burst pipes in case of frost, it is necessary that the outlets from the gutters should be protected by gratings (fig. 226), which may be of cast iron, or of galvanized-iron or copper wire. Similarly, the hopper heads should be so protected that nothing can enter them except through the nozzle outlet from the gutter, or through the swan-necked pipe from it.

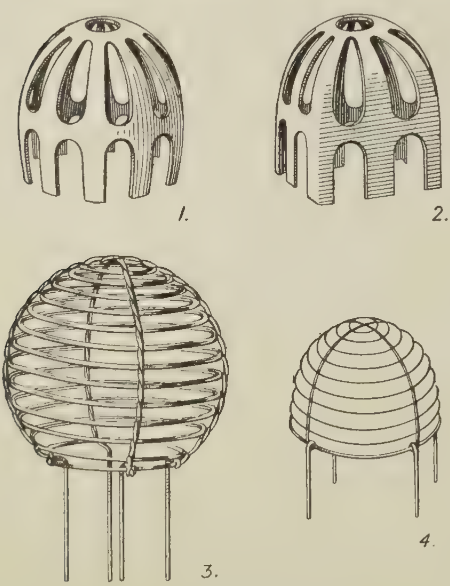



Fig. 226.—Gutter Gratings

Nos. 1 and 2, Cast iron; Nos. 3 and 4, Iron or Copper Wire.

**Special gutters** of a large size are supplied for boundary walls and valleys, and centre or trough gutters for M-shaped roofs, the water from which may be discharged through special down pipes, or down the interior of the cast-iron columns supporting the roof.

**Zinc gutters and rainwater pipes** are, for lightness and economy, sometimes used, and for gutters especially, when the roofs are covered with zinc. They can be obtained in lengths of 7 ft. and are extremely light. They should be manufactured out of pure zinc; otherwise they will not stand exposure to the air without deterioration, especially if iron is present. Zinc should not be used where likely to be exposed to

chemical fumes, or where cats have access; nor should it be fixed in contact with other metals, lime, or timber (such as oak) that contains acids.

The following is a table of equivalent gauges and weights per square foot:—

| Zinc Gauge. | B.W.G. | Weight per square foot. |
|---|---|---|
| 14. | 21. | $18\frac{3}{4}$ oz. |
| 15. | 20. | $21\frac{3}{4}$ oz. |
| 16. | 19. | $24\frac{3}{4}$ oz. |

For gutters nothing less than 15 or 16 gauge should be employed, and the moulded eaves gutters should be fixed with stays not more than 18 in. apart. The covering plates at the joints may either be plain or enriched.

On account of the expansion and contraction of zinc no nails or soldered joints should be used, and allowance must be made by giving plenty of play at the laps and joints. For gutters on flats a 2-in. drip should be allowed at each joint, the distance apart of the joints depending on the length of the sheets used. These are rolled in lengths from 7 ft. up to 10 ft.

Zinc rainwater pipes and elbows are made with soldered seams and slip joints, but are not often used.

**Lead Eaves Gutters.**—Lead is occasionally used for projecting gutters, and can be cast, like iron, into a variety of shapes; but on account of its great weight and lack of rigidity it must be stayed at frequent intervals. It is most extensively employed in forming gutters behind the parapet walls or cornices of roofs, or in lining valleys, where it is supported continuously either by the stone or boarding.[1]

**Lead rainwater pipes** are sometimes used, being made and fixed in a somewhat similar manner to lead soil pipes, but not necessarily out of such thick metal. They can be easily bent for any change of direction, such as for plinth bends or swan necks. Drawn-lead pipes suitable for the purpose are usually supplied in 10-ft. lengths.

The pipes are secured to the wall by means of *ears* (No. 2, fig. 227) similar to those used for cast-iron pipes, or by means of *tacks* (Nos. 5, 6, and 7), which are strips of lead about 9 in. or 10 in. in width, soldered to the backs of the pipes at intervals, and fixed by wall hooks driven through them into the walls. These tacks may be arranged in pairs (opposite each other) or singly on alternate sides of the pipe. With pipes out of 7-lb. lead, single tacks might be used at intervals of from 3 to 4 ft., but with heavier pipes double tacks should be used at every 5 ft. Double tacks look more symmetrical. The joints may be simple *wiped joints* (No. 8), but if it is intended to make the pipe more ornamental, it is usual to form what are termed *astragal joints* (No. 3), and the double tacks would be attached at these points. The tacks may be plain or ornamental, and if it is desired to hide the heads of the wall hooks, this can be effected by making the tacks a few inches longer, and then folding them back after the hooks have been driven in. Lead-covered nails are often used, as shown at No. 9.

Ornamental hopper heads of any size or design can easily be cast or formed in lead, but, as these are heavy, great care is necessary to secure

[1] For lead gutters on roofs, see Section III, Chap. I.

them properly to the wall. Plinth bends, shoes, and other accessories are also made in various stock sizes for round and rectangular pipes.[1]

**Sizes of Gutters and Pipes.**—Eaves gutters and rainwater pipes are frequently used of a larger size than that actually required. Assuming that the gutters are properly fixed and (with the down pipes) are kept

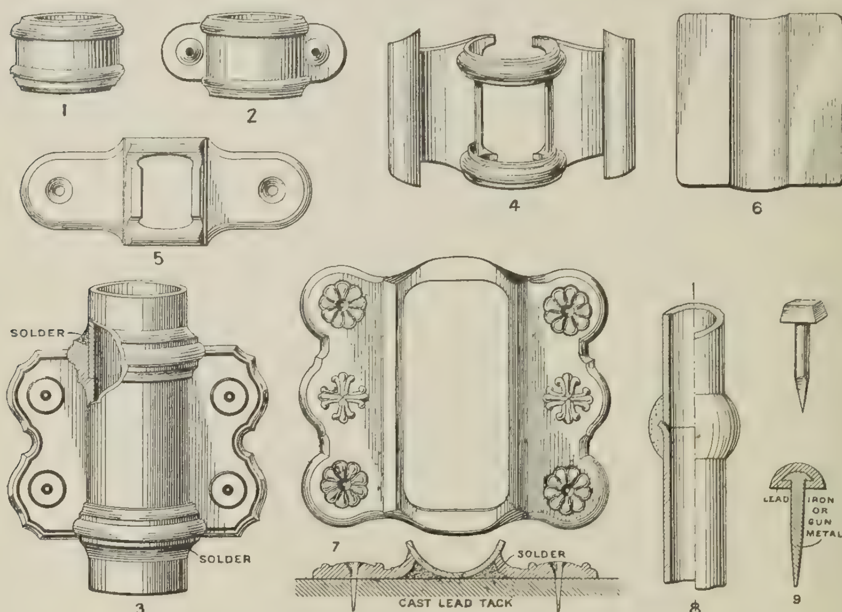



Fig. 227.—Connections and Fixings for Lead Rainwater Pipes

1, Socket; 2, socket with ears; 3, astragal joint and ornamental tacks; astragals and folded tacks; 5, cast tack; 6, sheet tack; 7, ornamental cast tack; 8, wiped joint; 9, nails.

clear of rubbish, a $3\frac{1}{2}$-in. gutter will take through one outlet the heaviest rainfall from a roof area of 300 sq. ft.

| | | | | | |
|---|---|---|---|---|---|
| 550 | sq. ft. can be dealt with by a | | 4 in. gutter | with one outlet. | |
| 800 | „ | „ | $4\frac{1}{2}$ | „ | „ |
| 1100 | „ | „ | 5 | „ | „ |

Outlets and down pipes of a diameter of 1 in. less than the gutters should be ample if placed near the middle of the run, and not more than 40 or 50 ft. apart. Except from large gutters or flats it is seldom that a down pipe larger than 4 in. is required.

**Details for Ordering.**—In ordering eaves gutters and down pipes for any special building, it is advisable to prepare a skeleton plan of the roof, with elevations, showing in each case their proposed positions, with all outlets, stopped or return ends and angles, and with all dimensions clearly figured. In the case of porches or projecting bays, their gutters, down pipes, or branches (leading into adjoining down pipes from the main roof), should all be carefully shown and fully dimensioned. The number or pattern of each,

[1] For further details of lead rainwater pipes, see Section III, Chap. IX.

together with the weight, should be marked as selected from the manufacturer's list, so that they can all be supplied properly marked and ready for fixing.

## *DRAINS FOR RAINWATER*

**Combined and Separate Systems.**—The arrangements for disposing of the rainwater, after it has been brought down from the roofs, depend on whether it has merely to be got rid of, or is required for domestic or other use. In the former case it can be connected with the foul-drainage system, or disposed of separately.

Where a combined system of drainage is adopted, the stack pipes should discharge over gullies, trapped to prevent them becoming ventilators to the foul drains (figs. 239 A, and 240).

Where there is a separate system of surface or storm-water disposal, there is not the same necessity for using trapped gullies, although some sort of catch-pit is desirable for the purpose of retaining the silt, &c., which may be washed down, and to prevent its being carried forward into the drains.

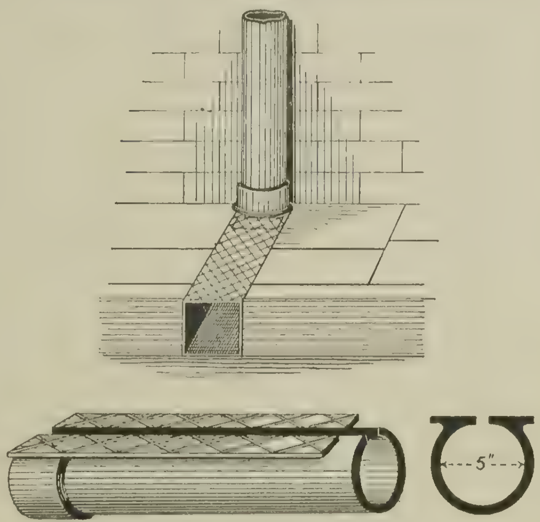



Fig. 228.—Cast-iron Surface Pipes or Channels

To reduce the number of these gullies or catch-pits, and to minimize the risk of dampness at the foundations of the house walls, which frequently occurs owing to the choking of the gullies, the stack pipes may be arranged to discharge their contents into surface-water channels leading away from the building. Where these surface channels are considered objectionable, as in crossing the pavement in front of street houses, the water can be conveyed in cast-iron channels square or circular in section (fig. 228).

**The drain pipes** used for the conveyance of water underground are usually made of stoneware or fire-clay, the former being considered the best. The texture of the stoneware is close and vitreous, whereas that of fire-clay is more open and spongy. Stoneware is practically non-absorbent, but fire-clay does take up a certain amount of water.

Stoneware pipes made from the Devon and Dorset clays were at one time considered the best, but the "granitic stoneware" manufactured by the Albion Clay Co., Ltd., from a judicious blending of different clays found in the Midlands, is of equally good quality as regards resistance to thrusting, bursting, and crushing.

Good drain pipes should be homogeneous in texture, cylindrical throughout and perfectly straight and smooth inside, impervious to moisture, with

well-formed sockets, and of uniform thickness throughout, strong enough to resist bursting under a moderate pressure, or crushing under a heavy load. To assist the impenetrability of the pipes they are highly vitrified and salt-glazed in the kiln when burnt. Inferior qualities are sometimes glazed with a lead or glass glaze, which is not incorporated in the pores of the material to the same extent as the salt glaze. Lead-glazing is frequently adopted for inferior clays, which will not withstand sufficient heat to allow of salt-glazing without losing shape.

To test a drain pipe for impermeability, a whole pipe or a broken piece should be weighed when perfectly dry, and again after immersion or boiling in water. The difference in weight will show the amount of absorption, which should be almost imperceptible.

Sometimes drain pipes are made of unglazed earthenware, a material similar to that used in the manufacture of ordinary bricks, but such pipes are only fit for subsoil drainage. They will not stand the heat necessary to ensure proper vitrification, without getting out of shape, and, besides being very porous, they are not so smooth as those made of stoneware, and are easily broken.

Stoneware pipes are manufactured in various sizes, from 2 in. upwards in diameter, and in lengths usually of 2 ft., exclusive of socket. Some manufacturers supply the larger sizes in lengths of 2 ft. 6 in. and 3 ft., and the number of joints is reduced in proportion, which is an advantage. Short pieces 6, 9, 12, and 18 in. in length can be obtained, which saves cutting whole pipes, and collars or sockets are also supplied for connecting plain or butt-jointed pipes. Special pipes, tested and stamped, for important work, are supplied by some manufacturers at an extra cost.

The average thickness of ordinary stoneware pipes is given below; fire-clay pipes should be a fraction thicker:—

| Internal diameter of pipe in inches | 3 | 4 | 6 | 9 | 12 |
|---|---|---|---|---|---|
| Thickness (average) " " | $\frac{1}{2}$ | $\frac{1}{2}$ to $\frac{5}{8}$ | $\frac{5}{8}$ to $\frac{3}{4}$ | $\frac{3}{4}$ to 1 | 1 to $1\frac{1}{8}$ |

**Joints in Drain Pipes.**—Whilst the quality of the pipes themselves may be considered of the first importance, it is also necessary to ensure that they are laid in such a manner as to render their joints absolutely gas- and water-tight when subjected to moderate pressures. It may not be necessary to secure such perfect workmanship in laying drains to take ordinary storm-water as for sewage, but the greatest care should be taken with those in which rainwater is conveyed to storage tanks for domestic use, or in a less degree to fire tanks. It is not so much the risk of leakage *from* the drains that is to be avoided as the danger of contaminated subsoil water finding its way *in*, and so polluting the water in the tank.

The cement used in all drainage operations should be the very best Portland cement, and for ordinary socket-jointed pipes it may be mixed in the proportion of from 1 to 4 parts of cement to 1 of sand; neat Portland cement, however, is usually specified for all important work.

Of the many forms of joint in the market all require care in workmanship and supervision during the operation of laying.

**Spigot-and-socket Joint.**—The oldest and most economical form is the ordinary spigot-and-socket joint (fig. 229), which, when carefully laid, gives perfectly satisfactory results under ordinary circumstances. This is known in Scotland as the spigot-and-faucet joint. The contiguous surfaces of the sockets and spigots are slightly roughened or grooved before the pipes are burnt in the kilns, so as to afford a better key or grip for the cement or other jointing material.

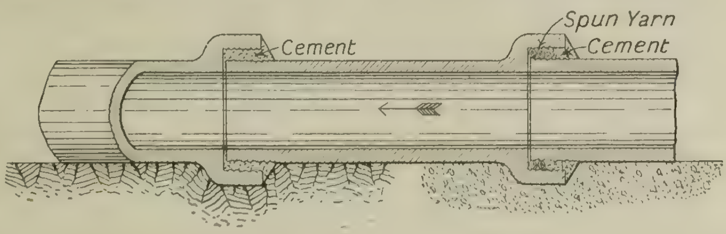


Fig. 229.—Spigot-and-socket Drain Pipes

Unless the utmost care is taken there is a risk of the pipes not being laid concentric, or that some of the cement may be squeezed through at the abutting joints, to form an obstruction later on, unless it is scraped off before it has set.

The lower half of the socket should first have a layer of cement spread over it, the spigot end of the next pipe should then be gently introduced over the cement until it touches the shoulder of the socket, when it is pressed down until the inverts are in line, the superfluous cement being squeezed up the sides or out at the front. The remainder of the socket should then be filled with cement, which must be well worked into the joint with a piece of wood shaped for the purpose, and the joint completed by being neatly "struck" round the outer edge of the socket, taking care that the lower portion also is well done. Before the next pipe is laid, a curved scraper should be passed over the inner joint to remove any cement which may have been squeezed through between the abutting ends.

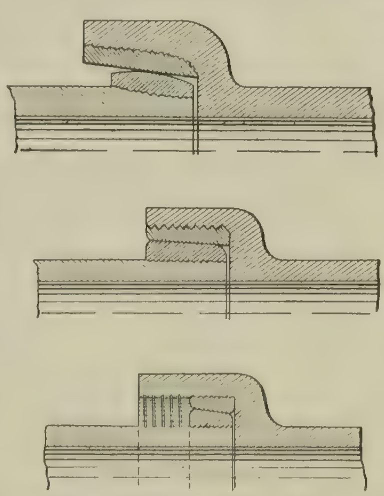


Fig. 230.—Three Varieties of the "Stanford" Joint for Drain Pipes

Sometimes, to ensure concentricity, the spigot end of the pipe is blocked up with the inverts in line, until the joint is formed, to prevent it from sinking slightly with its own weight on the green cement. Another plan is to force a few strands of hemp, spun yarn, or gasket, free from tar, and steeped in liquid cement, into the socket to centre the spigot end, and prevent any cement from being squeezed inside. The joint is then completed as before with stiff cement.

To obviate the difficulty of keeping the pipes concentric whilst being laid, and to ensure a more reliable joint, various contrivances have been adopted, with more or less success.

**The "Stanford" Joint** (fig. 230) consists of rings formed of a special com-

position, consisting of 1 part boiled tar, 1 part clean sharp sand or ground pottery, and $1\frac{1}{2}$ part sulphur, cast on the spigot and socket ends of each pipe, which fit mechanically into each other, forming a good joint, which may be completed with a fillet of cement. The composition on the spigot is slightly convex, that in the socket tapering, so that when put together they admit of a slight deviation in direction without affecting the joint.

**Doulton's Self-adjusting Joint** (fig. 231) is on similar lines.

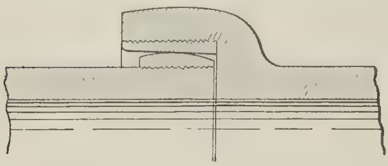


Fig. 231.—Doulton's Self-adjusting Joint for Drain Pipes

Before putting these pipes together, the surfaces of the composition should be carefully wiped clean and smeared over with a mixture of 2 parts Russian tallow and 1 part resin, melted together. The pipes are put together with a slightly twisting motion, and then gently tapped with a mallet, or forced home by means of a lever. Both kinds admit of the pipes being laid in water-logged ground, obviating the necessity for pumping the trenches dry, as the water can pass through whilst the pipes are being laid.

They can also be laid more quickly and accurately than the ordinary socket pipes jointed in cement, and, moreover, admit of a slight settlement of the ground without impairing the efficiency of the joint or affecting the concentricity of the pipes. They partake of the nature of a ball-and-socket joint, and can be readily taken apart if necessary.

Should there be any doubts as to the water-tightness of the joints as shown by the hydraulic test, a fillet of cement can be added to form a sort of double seal.

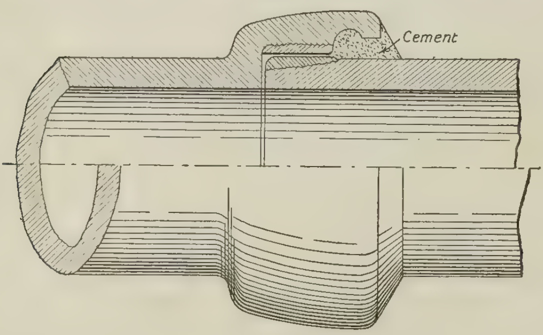



Fig. 232.—Tyndale's Double-seal Joint for Drain Pipes

**Tyndale's Double-seal Pipes** (fig. 232) are a combination of the Stanford and ordinary socket pipe, having a tapering rounded ring of a bituminous composition (tar, sulphur, and ground pipe) cast on the outer edge of the spigot and on the inner edge of the socket, slightly tapering, so that when the pipes are put together they form a concentric joint. The surfaces of the composition must be wiped clean and free from grit, and smeared with the mixture of melted tallow and resin; the spigot of the pipe to be laid is inserted with a slight twist into the socket of the pipe already in position, and then driven home by a few gentle taps with a wooden mallet.

Sometimes drains laid in this manner are tested and left in this condition if they do not show any signs of leakage when filled with water, and, whilst they allow of slight settlement without causing leakage, admit of being readily taken up again when required. In important work, however,

the "double seal" is adopted and the cement fillet added. The sockets are made extra deep, and an under-cut groove formed outside the bituminous ring gives a good hold to the cement, which should be carefully filled in with the fingers and gently rammed or tapped to consolidate it.

**Archer's Patent Joint** (fig. 233) has an annular groove in the socket of one pipe and a projecting tongue on the other, which fits loosely in the groove. Bands of plastic composition, or well-tempered clay, are placed against the inner and outer shoulders at the base of the tongue only, and the pipes are pressed home. Liquid cement (3 of Portland cement to 2 of water) is then poured in at one of the two holes on the top, until the whole of the annular space is filled up. Great care is requisite that the grout should be poured in at one hole only. An inexperienced workman will probably pour in at both holes at the same time (as they are close together), or alternately, with the result that bubbles of air will remain, and so reduce the efficiency of the joint. A small cup formed with clay should be made round one of the holes, so that the grout can only enter that one.

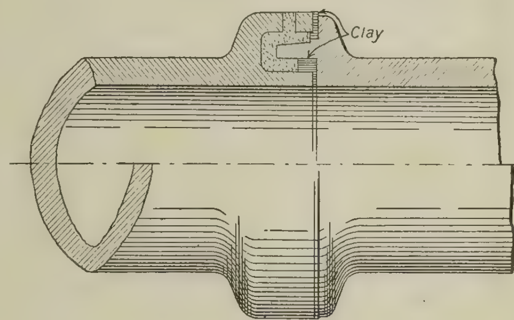



Fig. 233.—Archer's Patent Joint

**Hassall's Patent Safety Pipes** (fig. 234) are manufactured in two forms, the single- and the double-lined. Rings of bituminous composition are cast on the spigots and sockets, ensuring a true invert line. In the single-lined pattern the outer edge is closed with a band of clay, whilst the double-lined has a second or outer pair of composition rings; in each case an annular groove is formed which is filled with liquid cement as before.

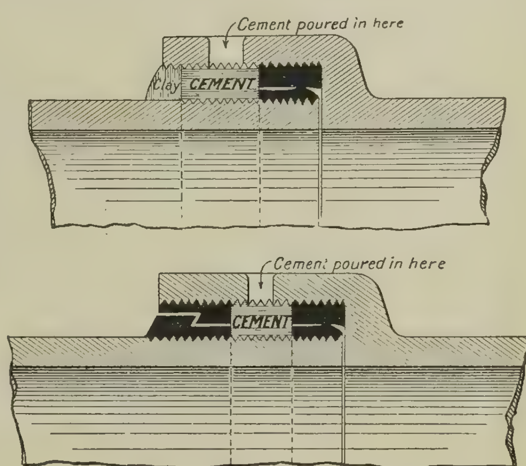



Fig. 234.—Hassall's Single-lined and Double-lined Joints

**Sykes's Patent Screw-joint Pipes** (A, fig. 235) are manufactured by the Albion Clay Co., Ltd., in their "granitic stoneware". Male and female screw threads of a bituminous composition are formed on the spigot and socket ends of the pipes. A strong rim or collar is formed on the spigot end, against which a band or fillet of special jointing material is placed; when the pipes are screwed together this composition is compressed between the end of the socket and the face of the rim, a portion being worked forward

between the threads, thus forming a water-tight joint. The jointing material is mixed on the spot, in small quantities, to about the consistency of glazier's putty, with a fluid supplied by the manufacturers, and old Portland cement, and it is said to be both impervious and imperishable.

The great advantage of these pipes is that they can be laid in water-logged ground, or even under water, as the plastic composition sets in water. The pipes can be partly screwed up by hand labour, but the Company supplies chain tongs to screw them home thoroughly.

**Sykes's New Patent Joint** (B, fig. 235) is another form of spigot-and-socket joint having rings of bituminous composition cast on to ensure concentricity, and leaving an annular space to be filled with liquid cement grout to complete the joint. A thin fillet of grease is first put upon the black composition

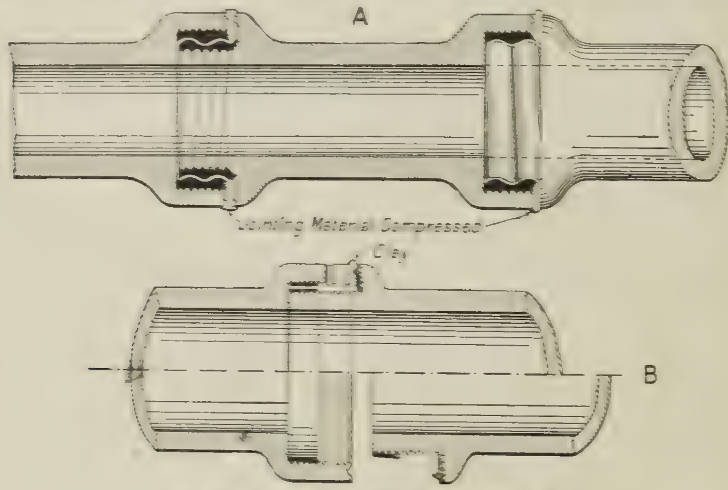



Fig. 235.—Sykes's Patent Joints. A, Screw; B, New

in the socket, and then a fillet of well-worked but not too stiff clay is placed against the inner face of the rim on the spigot end of the pipe. The pipes should then be pushed home thoroughly by placing a chock against the end of the socket and tapping it with a hammer or mallet. This compresses the clay, and the joint is completed by pouring in liquid cement grout as before, none of which can find its way into the pipe to cause obstruction.

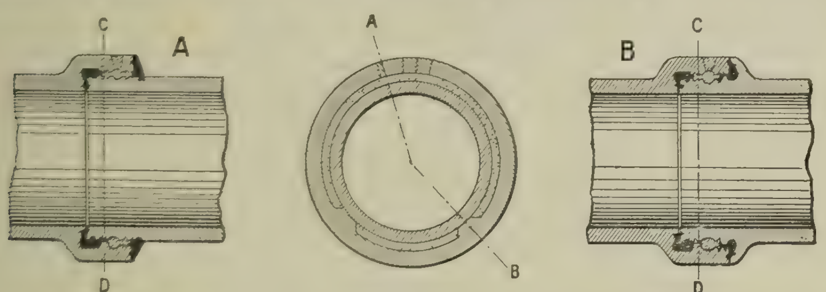
Whilst the provision of these rings of bituminous composition ensures true alignment of the inverts, there is always the risk of their being damaged during transit or by rough handling. Various forms of pipes can be obtained having studs or supports cast on the lower portions of the sockets, which support the spigots, so that they cannot drop below the general alignment when once they are inserted in position. Clay and cement are then the only jointing materials required.

**Self-adjusting Joints.**—Ames and Crosta's Patent Self-adjusting Single and Double Seal Pipe Joints (fig. 236) are of this pattern, as is also the "Loco" Drain Joint. The Patent Paragon Pipes are also made with solid

supports, ensuring concentricity, and moreover are formed with flat-bottomed sockets, which afford a firm bed and prevent rocking when walked on.

There are many other forms of joints, including that of Messrs. Freeman Hines, Ltd. This is a locking joint ensuring concentric fitting and close abutting of ends.

**Bends, Junctions, Taper Pipes,** &c. (fig. 237), can be obtained to suit the different patterns of pipe. The bends may be plain, short, long, sharp, easy, quadrant, or taper, and either with or without inspection eyes or stoppers. Pedestal or foot-rest bends are also made for the foot of rainwater or other pipes fixed vertically. The junctions may be single or double, and oblique or curved, suitable for various angles; also bend or taper, and all with or without inspection eyes as before. Square junctions ought not to be used.




Single seal — Section on CD — Double-sealed joint for water-logged ground

Fig. 236.—Ames and Crosta's Self-adjusting Joints

Taper pipes may be long, short, special, or curved, and with collars or sockets at either end as required.

**Channels** for inspection chambers or manholes may be straight, curved, or taper, and with bends or junctions for branch drains entering the chambers at different angles, and may be either salt-glazed or enamelled.

**Plan of Drainage Area.**—Before the actual work of excavating the trenches for the drains can be commenced, it is necessary to prepare a plan showing the whole area or site to be drained, with the position of the outfall, so that the various levels can be fixed and the falls to which the drains are to be laid ascertained. The plan should show the position of all the buildings from which it is intended to collect the rainfall, also that of any specially prepared surface to be used as a gathering-ground, the rainfall from which it is intended to store.

The position of the tank should also be shown, with the direction of the various branch and collecting drains, to enable the level to be fixed at which the tank is to be built, after allowing for sufficient fall to the drains from the extreme points. The falls may vary from 1 in 40 to 1 in 60 for 4-in. pipes, and from 1 in 60 to 1 in 90 for those 6 in. in diameter, or even flatter still, as no sediment has to be carried along. Every inch beyond what is actually necessary necessitates extra excavation, not only for the tank itself but also for the drains. At the same time care must be taken that the drains at their highest points are laid at a sufficient depth below the surface of the ground to enable them to stand ordinary traffic over

them without fracture. It may be found more economical to lay some of the drains near the surface and encase them in concrete, or to use cast-iron pipes for conveyance of some of the water, rather than increase the depth to which the tank might otherwise have to be taken.

In important work it is usual to collect the branch drains into brick manholes or inspection chambers, from which the main drains would be taken to the outlet or underground tank (Plate XII).

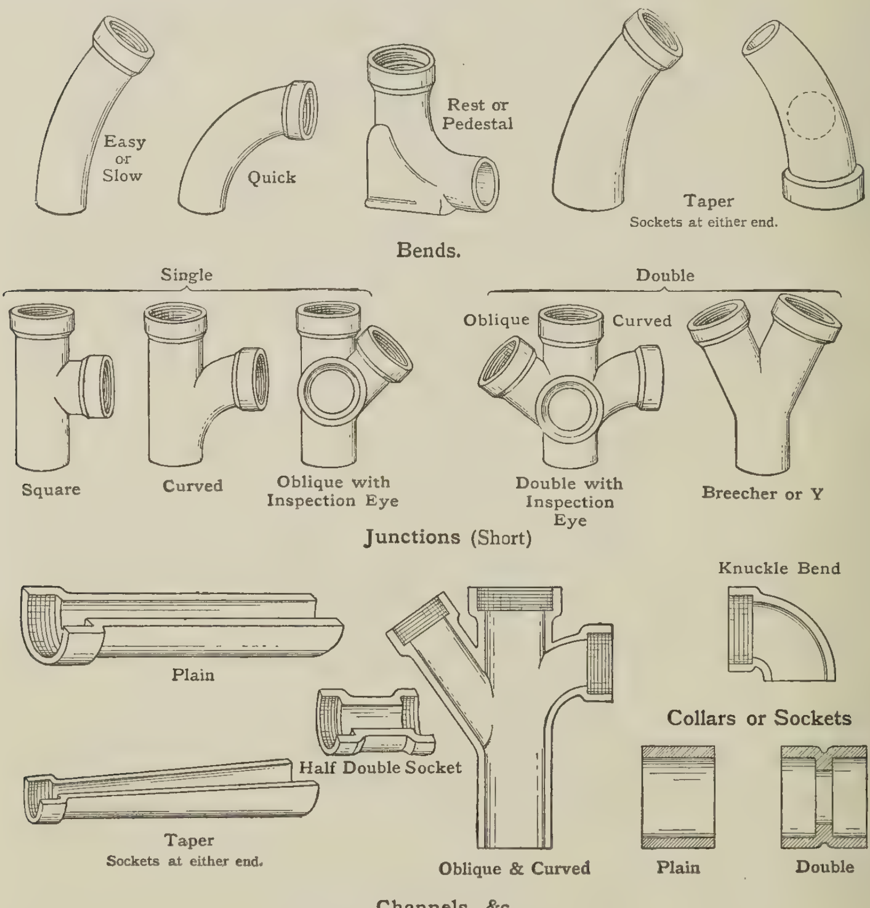



Fig. 237.—Bends, Junctions, Channels, &c.

**Preparing the Trenches.**—The above points having been settled, pickets should be driven in at the various changes of direction or gradient, and at the junctions, with the levels for the inverts marked; then by means of sight rails and boning rods the trenches can be excavated to their proper depth at once.

If any extra depth is excavated, the necessary filling must be carefully done by ramming in suitable material, or making up with concrete if there is much of it, so as to obviate any risk of future subsidence causing fracture.

If the bottom of the trench is found to be virgin soil, and naturally solid, the pipes may be laid directly on it, after well ramming it if necessary, but if it is "made" ground, or soft and damp, it will be necessary to lay a bed of concrete for the pipes to rest on.

It is usual to make the trenches for drains about 12 in. wider than the diameter of the pipes, so as to give the workmen room to work, and where a concrete bed is used it should be the same width as the trench, and 4 in. or 6 in. in thickness according to circumstances (A, fig. 238). When laid, the pipes should rest solidly on their barrels (C), and not on their sockets (B), as is so frequently the case when there is lax supervision. Hollows or pockets should be formed in the bottom of the trench at suitable distances apart to receive the sockets, to enable the barrels to rest solidly throughout their length, and to afford space for the hand to form the joint. When concrete is used, moulds of wood are usually inserted at the requisite

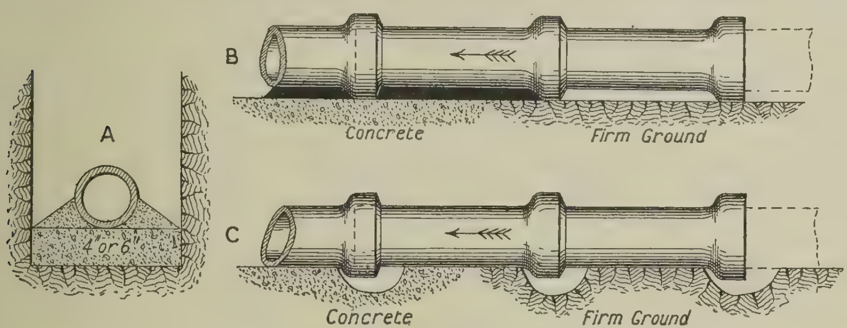


Fig. 238.—Drain Pipes in Trenches

intervals to form the pockets, and removed as the pipes are being laid, the space being afterwards carefully packed with fine concrete. As there is more danger of the pipes crushing when laid on a hard surface of concrete, than when resting on slightly yielding soil, it is a good plan to haunch up the sides with concrete to half the height (A, fig. 238), in order to distribute the pressure over a larger area. The haunching also affords further security to the joints in the lower half of the pipe, where the current would usually flow. It should not, however, be done until after the hydraulic test has been applied and the joints have been proved to be sound.

**Laying the Pipes.**—As drain pipes should be laid with their sockets facing against the flow, work must be commenced at the lower ends of the drains, and continued from point to point, a line being stretched from end to end of each length or section, to ensure that the proper alignment is kept in plan.

**The Hydraulic Test.**—After each section has been completed, and the cement joints set, and before the trench is filled in, the hydraulic test should be applied. This consists in filling the drain with water, a removable stopper being inserted into the mouth of the lowest pipe. A bend can be inserted in the upper pipe, and if considered necessary one or more pipes can be fixed vertically in the bend, so as to give an extra head of pressure. These temporary joints can be formed with well-tempered clay. When the pipe has been filled to the brim, any leakage will be shown by a lowering

of the water level. This, if slight, may be caused by absorption of water by the pipes themselves, or at the joints, and may soon cease. If serious leakage is found to be taking place, however, efforts must be made to locate and make good the defect.

**Filling-in the Trenches.**—If after (say) a couple of hours there is no further subsidence in the water level, the drain may be considered sound and the trench can be filled in, after the concrete haunching already mentioned has been formed where required. It is a good plan to let the water remain until the filling-in has been completed, to ensure that no injury has been caused to the pipes or joints during the process.

This filling-in requires to be very carefully done, so as not to injure the

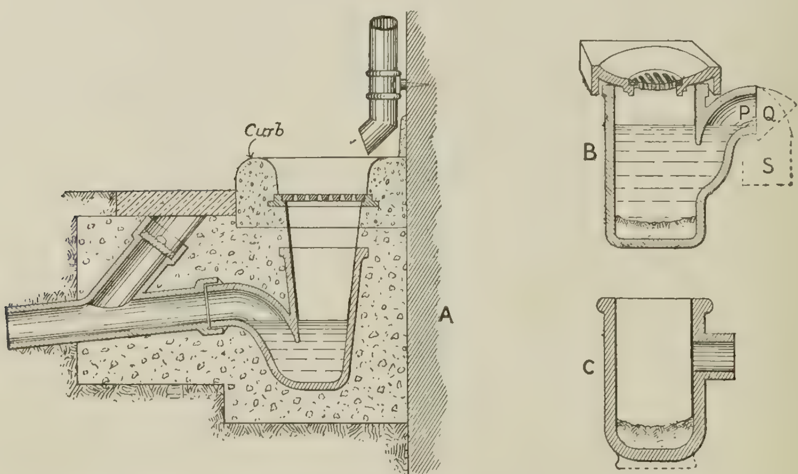



Fig. 239.—Gullies. A, Trapped Gully, with Cleaning Arm and Stopper, and Concrete Curb; B, Trapped Silt Gully; C, Trapless Silt Gully

pipes by throwing stones or clods on the top of them, or by commencing the ramming too soon. The smallest stuff should be utilized first to fill up the spaces between the sides of the trench and the pipe, carefully working it under the shoulders of the pipes so as to support them where there is no concrete.

**Gullies** may all be classed under one of two patterns, viz. self-cleansing and catch-pit gullies.

When rainwater from the roofs is connected with the foul-drainage system, the down pipes should discharge into trapped gullies (A, fig. 239). When there is a separate system of storm-water drainage, trapped gullies (B, fig. 239) are sometimes used, although the trap may not be required for sanitary reasons, but simply to retain the silt, &c., brought down from the roofs and so prevent it getting into the drains and rainwater tank. Trapless gullies (C, fig. 239) are also used for this purpose, the grating catching the leaves, birds' nests, &c., which may come down, and the finer silt being retained in the gully. Fig. 240 shows how a rectangular rainwater pipe can be connected to a gully or drain by means of special connecting pieces.

Sometimes the gratings provided with gullies are of perforated stoneware, but galvanized iron is better. Loose gratings are liable to be removed and lost, to avoid which they should be hinged, and their frames either run with lead into dished stones, or secured in the concrete curb round the top of the gully.

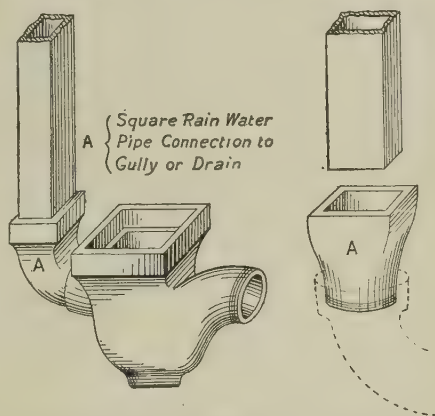



Fig. 240.—Gully with Back Inlet and Connections to Rectangular Rainwater Pipe

When a gully is set to take the surface drainage of a yard or paved surface, the grate is laid in a shallow dish of stone, stoneware, or concrete, but when it is intended to take the discharge from a rainwater pipe, or the waste from any of the house fittings, it is usual to form a curb round it to prevent splashing. Special stoneware dished curbs can be obtained, but a very good one can be formed of concrete on the spot (A, fig. 239). The gully itself should be bedded on and encased in concrete composed of about 1 part Portland cement to 4, 5, or 6 parts of gravel, &c., and after the gully and drain from it have been tested the curb can be formed *in situ* with finer concrete, which may be floated with cement and granite siftings as a finish.

Where they are likely to be subjected to rough usage, the curbs are

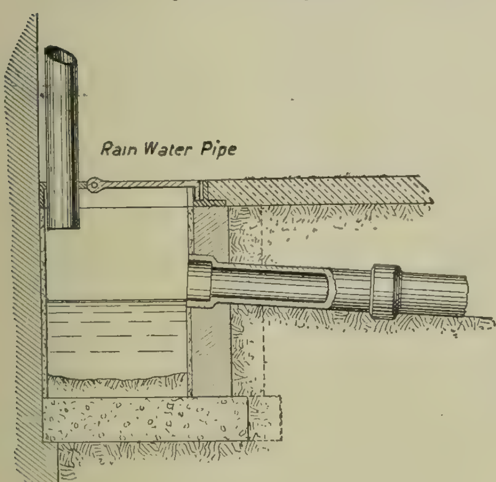



Fig. 241.—Brick Catch-pit

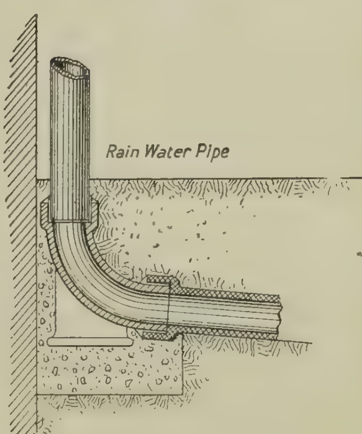



Fig. 242.—Pedestal Bend connecting Rainwater Pipe and Drain

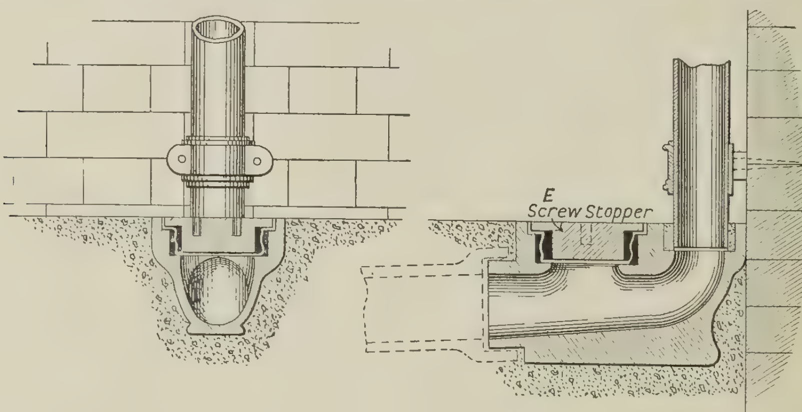
frequently specified to be composed of 1 part Portland cement to 2 parts of granite chippings or crushed flints, and may be from 4 to 6 in. thick, and from 3 to 9 in. deep, with rounded tops, the finished surfaces being trowelled smooth in Portland cement.

The gully should be set sufficiently forward from the wall to admit of a

cement skirting being carried up at the back, as otherwise the splashing may render the walls damp.

Gullies can be obtained with what are termed P, Q, or S outlets (B, fig. 239), and of any diameter to suit the drain, and also with back or side inlets to take additional branches if required. A gully with back and side inlets can be utilized to take the discharge from two or three down pipes, and if the branch drains are short any obstruction at the feet of the down pipes can be cleared from the gully itself.

**Catch-pits, Bends, and Shoes.**—Where the roof water is intended to be stored in an underground tank for domestic use, it is better to carry the




down pipes direct into a brick catch-pit having a hinged or movable cover, which can be opened for cleaning out the pit (fig. 241), or into the collecting drains, as shown in fig. 242, to avoid any danger of slops, &c., being emptied into the gullies.

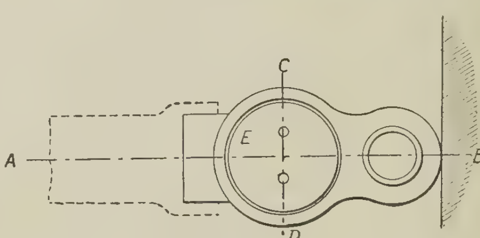



Fig. 243.—Rainwater Shoes. Plan and Sections AB and CD

Another method, which admits of inspection at the ground level, is to use a rainwater shoe to receive the lower end of the down pipe (fig. 243), the shoe having a screw stopper E, or solid movable cover, instead of a grating.

### *STORAGE AND FILTRATION OF RAINWATER*

The Rivers Pollution Commissioners, in their sixth report, state that: "Rainwater is in reality water which has washed a more or less dirty atmosphere and is laden with mineral and excrementitious dust, zymotic germs, and the products of animal and vegetable decay and putrefaction". It follows, therefore, that when it is intended to collect it for storage and subsequent use for domestic purposes, some means should be adopted for running to waste the first portion of the rainfall, which has taken up the impurities not only from the atmosphere, but also from the roof itself.

**Roberts's Rainwater Separator** is an ingenious contrivance for automatically disposing of the first washings from roofs or other collecting surfaces. It is not intended to act as a filter, but simply to reject the dirty water and store the clean.

It is made of various capacities according to the areas of the collecting surfaces, and can be arranged for fixing either vertically or horizontally. If the whole of the roof water is brought down by a single stack pipe, a vertical separator (fig. 244) would be used, fixed above the ground level, but if there are a number of down pipes connected with an underground storage tank, one of the horizontal type (fig. 245) should be fixed in a pit underground on the main drain to which all the down pipes had been connected.

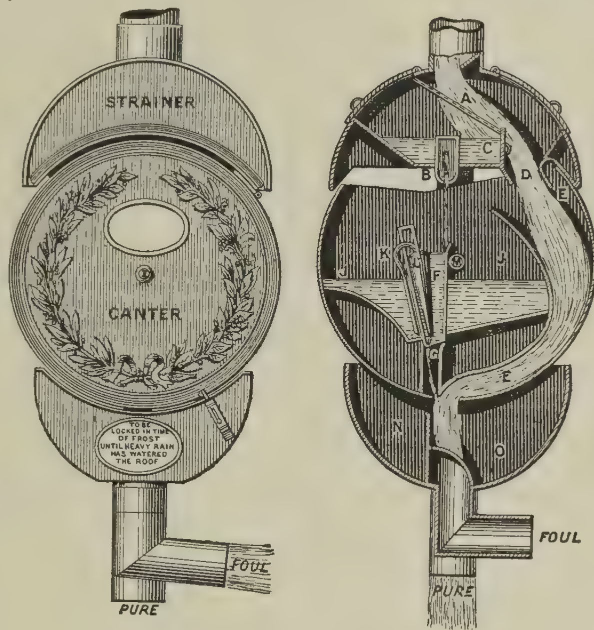



Fig. 244.—Roberts's Vertical Rainwater Separator

The amount of water required for effectively washing down a roof will vary from 1 to 3 gal. per 100 sq. ft. of surface, a slated roof requiring less than a tiled one, and a roof in the country less than one in town.

It is sometimes convenient to have the rainwater stored in a cistern in the upper part of the house, to supply water by gravitation to the house fittings, in which case a horizontal separator might be fixed under the eaves, or over the cistern, for convenience of access from the inside of the house. Where this is not practicable, arrangements may be made for pumping the water from the underground tank to the storage cistern in the building.

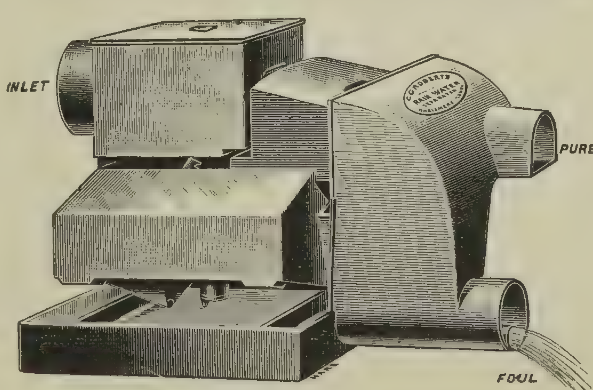



Fig. 245.—Roberts's Horizontal Rainwater Separator

Of course proper provision must be made in each case for protecting the separators against frost, and for disposing of the foul waste water, which must be treated as other wastes and discharged over or into trapped gullies.

These separators are made of zinc on an iron frame, the centre part, which is called the canter, being balanced on a pivot. They are self-acting, and after being properly fixed and adjusted are said to require no further attention except periodically washing out. This is absolutely necessary to secure proper working, as an accumulation of fine silt is liable to stop up some of the small holes which regulate the action of the canter.

When the apparatus is in its normal position as first fixed, the roof water passes out through the foul outlet, but after a certain amount has been discharged (from 1 to 2 gal. per 100 sq. ft. of roof), the canter tips over and directs the flow of water into the clean-water outlet.

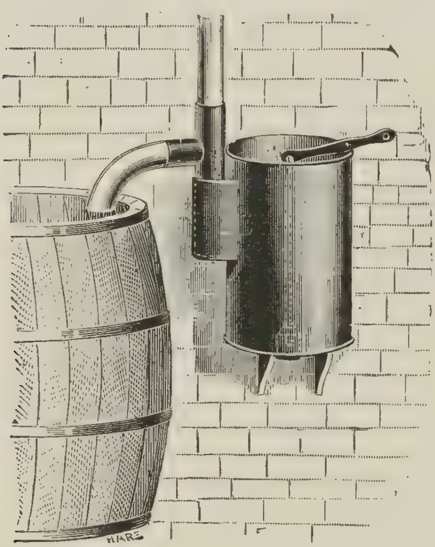


Fig. 246.—Roberts s Roof-washing Tank

This result is obtained by means of an ingenious arrangement by which a small portion of the water which first enters the separator flows into the canter, and on rising to a certain level causes it to tip over on its pivots sufficiently far to close the outlet for the impure water and direct the flow through the clean-water outlet. If the rain is not sufficient to wash the roof thoroughly, it passes through the separator without causing the canter to tip.

By another arrangement, for slowly emptying it, the canter is prevented from immediately resuming its normal position, so that should another shower take place within two or three hours, the clean-water outlet would still be in operation.

There are small variations in the internal arrangements of the vertical and horizontal patterns, but the principle in each is the same.

The different sizes of separator are guaranteed to take a rainfall (in rural districts) at the rate of 2 in. per hour on areas of roof ranging from 600 to 5000 sq. ft. In tropical countries, where the rainfall occasionally exceeds 2 in. per hour, and in smoky cities, larger separators are required than in the rural districts of this country.

**Roberts's Roof-washing Tank** (fig. 246) is made in two sizes, and is a cheap and simple contrivance for obtaining the clean water from the roofs of cottages or small buildings where the separators may be considered too large or too expensive. It is designed to retain the dirty water which first comes from the roof, and to direct the clean water, which comes down afterwards, into the storage tank. The dirty water should be emptied out at intervals not exceeding one week, to prevent the sediment from becoming

offensive, and to be ready for the next fall of rain. This can be done by means of the lever, which raises the valve shown by dotted lines.

Fig. 246 shows the washing tank fixed so as to deliver the clean water into a water butt, which should be provided with a cover and draw-off tap. If it is intended to store the whole of the rainwater, tankage accommodation should be provided for a rainfall of 4 in. This is about equal to 1 cu. ft. for each 3 sq. ft. of horizontal surface covered by the roof. Thus, for a roof measuring 300 sq. ft., a tank 5 ft. square and 4 ft. deep, or a circular one 5 ft. in diameter and 5 ft. deep would be ample.

The **receptacles for rainwater** may either be cisterns in the roof or other suitable position, water butts above the ground level, or tanks formed underground. In a house containing two or three stories, with lower outbuildings, it may be practicable to store the water collected on the highest roof in a cistern at a high level, either outside or inside the house, thus rendering it possible to supply by gravitation the fittings on the lower floors, and saving pumping or the labour necessary in carrying the water upstairs. Overflows must be provided of sufficient capacity to carry away the maximum amount of rainfall without flooding the building. The overflows may be arranged to discharge into one or more water butts fixed at the ground level, or into an underground tank.

**Water Butts.**—As ordinary butts contain only a limited amount of water (say from 100 to 200 gal.) they are soon filled, and the surplus water runs to waste and is consequently lost, unless the overflow is led into an underground tank. Occasionally two or more butts are fixed side by side, and connected by a pipe passing through their sides. Each butt should be provided with a hinged or movable cover, which will keep out dirt and can easily be raised when the butt requires cleaning out. The draw-off tap should be fixed a few inches above the bottom, so that, whilst most of the water can be drawn off, the sediment will not be disturbed.

It is desirable that a plug should be fixed in the bottom, so that when it is withdrawn the interior of the butt can be thoroughly cleaned out. Instead of a plug a removable standing waste-pipe may be used, which would serve as an overflow. The butt should be raised a little above the ground level, and a channel formed to lead away the waste water when the overflow is in operation, instead of letting it soak into the ground and so create a nuisance close to the building.

To prevent the noise caused by the inrushing water, as well as the stirring up of the sediment at the bottom, the stack pipe is sometimes continued down to the lower half of the butt, and a plate fixed a few inches clear of its bottom causes the water to be thrown out sideways. The heavy sediment which settles at the bottom is not disturbed, and the lighter matter, such as leaves or soot, rises to the top and can be skimmed off.

**Wooden cisterns or tanks** can be made of any convenient capacity, but should be sufficiently strong to resist the pressure of the water, which may be taken approximately at $\frac{1}{2}$ lb. per square inch for every foot in depth. Horizontal tie-rods can be inserted to keep the sides from being forced outwards, and in large tanks bolts are fixed vertically through the sides to keep the joints water-tight. All the joints should be carefully housed

or ploughed and tongued, and put together with red and white lead. The tanks should be provided with close-fitting covers to keep out dirt.

As a further precaution they may be lined with sheet lead or zinc, and, although the rainwater may be injuriously affected by these metals when it is required for drinking or cooking purposes, it is quite immaterial when it is to be used only for washing, bathing, flushing water closets, or any similar purpose.

**Galvanized wrought-iron tanks** are often used, and although the rainwater is affected by the coating of zinc, the material is on the whole more satisfactory than wood. Cast-iron and steel tanks are also employed, and are more fully described in Chapter VIII.

The best materials for rainwater cisterns of moderate size are **stoneware** and **rubbed slate**; the slate slabs must be carefully jointed with neat Portland cement, and fixed with wrought-iron tie-rods.

**Underground Tanks.**—Underground tanks may be constructed of stone or brickwork built in cement, or may be of concrete (Plates XII and XIII). The walls should be made impervious, so as to prevent leakage from the inside or the risk of pollution by the entry of contaminated subsoil water from the outside. This is effected by rendering the inner and outer faces of the walls with cement and sand in equal proportions, or, instead of the outer rendering, a backing of clay-puddle may be carefully applied as the filling up at the back is carried out.

The walls should be strong enough to resist the pressure of the water when the tank is full, as well as that exerted by the earth behind when it is empty. The thickness of the walls can be reduced towards the top, but if the tank is to be arched over, the side walls must be strong enough to resist the outward thrust of the arch.

When it is desired to keep the tank at as high a level as possible, it is a common practice to cover it with rolled-steel joists and concrete, laid with a fall sufficient to throw off the surface water. The top should be finished either by floating with cement or by a layer of asphalt to prevent percolation. This surface may be exposed, or it may be covered with earth or gravel, according to surroundings. The manhole covers provided for access should project slightly above the surface of the concrete or soil.

The actual shape of the tank will depend upon its capacity. It is better within certain limits to make it oblong in plan, so as to reduce the span, and it may be an advantage to form a large tank in two or more compartments, so that cleaning out or repairs can be carried out in one whilst the others remain in use. The cross walls separating the compartments should be strong enough to resist the pressure of water when one compartment is empty. Circular tanks can be more easily built watertight than rectangular ones, besides being more economical in the materials employed, as the walls tend to counteract the thrust of the earth behind, as in wells. The hexagonal plan is almost equal to the circular in these respects, and is superior to it where tanks are grouped together.

The floors may be formed of concrete on a layer of puddle, and should be laid with a fall to facilitate cleaning out. Sometimes a small pit or "sump hole" is formed in the lowest part of the floor, so that all

the sediment which collects at the bottom of the tank can be swept into it and then hoisted to the surface by means of buckets.

Where the fall of the ground permits, it is well to have a wash-out pipe laid from the lowest corner of the tank and governed by a sluice valve, so that when empty the tank can be thoroughly cleansed down and washed out.

Whatever form of tank is used, it is necessary to have a manhole for access for cleaning out or inspection purposes, also movable covers over filters and catch-pits. Means of ventilation must also be provided, but light should be excluded, so as to prevent vegetable growth. Plate XIII shows a rainwater tank to contain 7500 gal., with a catch-pit for detritus and a double filter of sand and gravel; two handy kinds of pump are also shown. The tank in Plate XII was provided principally for watering a rose garden at a lower level, and as filtration was unnecessary, the water was simply passed through a grit chamber, having a scum board across at the water-level.

**Capacity of Tanks in relation to Rainfall.**—Before deciding on the actual size of an underground tank several points must be considered, such as the available area of the gathering-ground or collecting-surface; the probable daily consumption to be provided for; the average rainfall of the district; and the loss due to evaporation and other causes.

For a town house, the available collecting-surface would probably be the roof only, and in calculating this area it must be remembered that the horizontal dimensions only should be taken, that is, the plan of the roof or roofs, and not the area of the slopes. A town house would doubtless have a public water supply laid on, so that the chief reason for collecting and storing the rainwater would be on account of its softness and suitability for washing and laundry purposes, a great advantage when the public supply is hard.

As the cost of an underground tank increases very much, according to its depth and extent, it would probably be kept within moderate limits in a town, and arrangements might be made to collect some of the rainfall in a cistern in the upper portion of the house, and part in one or more butts, and to run the remainder into the tank.

A country house, with its outbuildings and surroundings, would afford a larger catchment area than the average town house, and if the supply is to be entirely dependent on the rainfall, storage capacity for at least three or four months ought to be provided for. In the eastern districts of this country provision should be on the larger scale, the average rainfall being less, and the times of fall more irregular, than in the west. Moreover, there may be long periods of drought, and the requirements from time to time may also vary according to the number of occupants.

It may sometimes be found practicable and desirable, where the stables, laundries, and other outbuildings are detached from the main block, to have a separate tank for the storage of the rainwater from the roofs of these buildings, and even from clean paved or gravelled surfaces which have not been exposed to pollution by animals, &c.

Unless properly filtered, this water might not be fit for drinking or cooking, but it would be most useful for washing, watering, and also as a reserve in case of fire.

**Cubical Contents of Tanks, &c.**—In calculating the capacity of a square or rectangular tank, the length, width, and depth in feet, multiplied together, will give the contents in cubic feet, which, multiplied by $6\frac{1}{4}$ (the number of gallons in a cubic foot), will give the capacity in gallons.

Thus, to find the capacity of a tank 20 ft. × 10 ft. × 6 ft. deep, as shown in Plate XIII:—

$$\overset{\text{L.}}{20\,(\text{ft.})} \times \overset{\text{B.}}{10\,(\text{ft.})} \times \overset{\text{D.}}{6\,(\text{ft.})} \times 6\tfrac{1}{4}\,(\text{gal.}) = 7500 \text{ gal.}$$

To find the capacity of a circular tank, cistern, or well, square the diameter in feet and multiply by ·7854 to obtain the area of the bottom; then multiply by the depth (also in feet), and by $6\frac{1}{4}$ as before. Thus, for a tank or well 8 ft. in diameter and 7 ft. 6 in. deep:

$$8\,(\text{ft.}) \times 8\,(\text{ft.}) \times {\cdot}7854 \times 7\tfrac{1}{2}\,(\text{ft.}) \times 6\tfrac{1}{4}\,(\text{gal.}) = 2356{\cdot}2 \text{ gal.}$$

It is sometimes considered sufficient to provide storage accommodation for an available rainfall of 4 in. Suppose that the catchment area is 2600 sq. ft., and that an available rainfall of 4 in. has to be stored:—

1 inch of rainfall = ·52 gal. per square foot.
2600 × ·52 × 4 (in.) = 5408 gal.
A rectangular tank 16 ft. × 9 ft. × 6 ft. will contain 5400 gal.

Or a circular tank 10 ft. in diameter and 11 ft. deep would suffice:

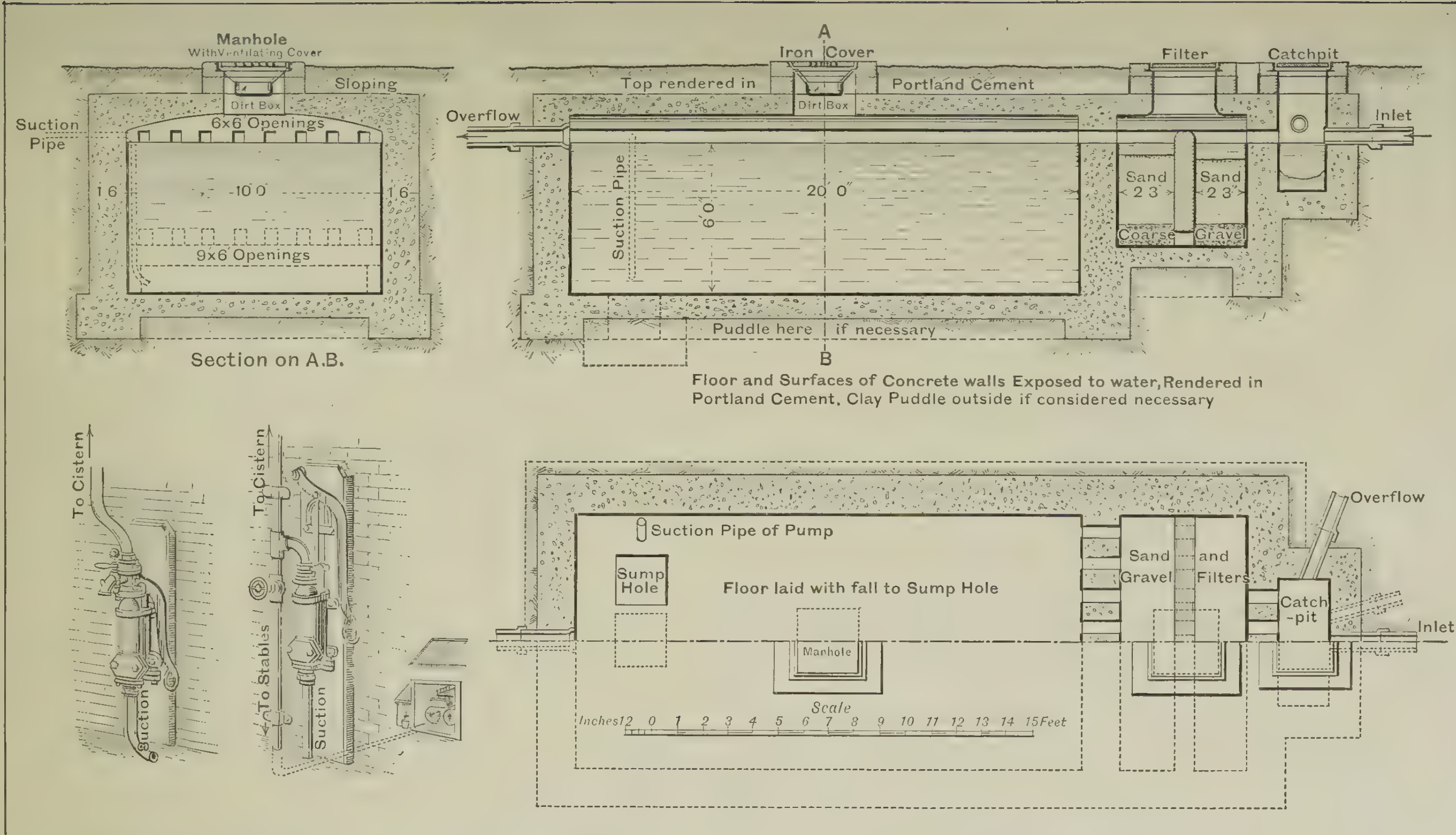
$$10 \text{ ft.} \times 10 \text{ ft.} \times {\cdot}7854 \times 11\,(\text{ft.}) \times 6\tfrac{1}{4}\,(\text{gal.}) = 5400 \text{ gal. nearly.}$$

TABLE OF CONTENTS OF CIRCULAR TANKS OR WELLS IN GALLONS

| Diameter of Cir. Tank or Well. ft. | in. | No. of Gallons per foot in depth. | Diameter of Cir. Tank or Well. ft. | in. | No. of Gallons per foot in depth. |
|---|---|---|---|---|---|
| 4 | 0 | 78·4 | 8 | 6 | 354·2 |
| 4 | 6 | 99·2 | 9 | 0 | 396·9 |
| 5 | 0 | 122·5 | 9 | 6 | 442·2 |
| 5 | 6 | 148·0 | 10 | 0 | 490·0 |
| 6 | 0 | 176·4 | 10 | 6 | 540·2 |
| 6 | 6 | 207·0 | 11 | 0 | 592·9 |
| 7 | 0 | 240·0 | 11 | 6 | 648·0 |
| 7 | 6 | 275·6 | 12 | 0 | 705·6 |
| 8 | 0 | 313·6 | | | |

*Rule.*—Diameter in feet squared × 4·9 gives approximately the quantity of water in gallons per foot in depth.

**Collecting Area and probable Daily Supply.**—If the water supply for a house or community is to depend entirely on the rainfall, careful calculations must be made as to the total amount of water required, so that a sufficient area of collecting surfaces may be set apart for the




UNDERGROUND TANK TO HOLD 7500 GALLONS

Half-plans above and below the Top; Longitudinal and Transverse Sections; and views of Pumps

purpose. In estimating the amount of rainwater which may be collected on this area, the average rainfall of the district is misleading; the average of the three driest years is a safer basis of calculation, and sometimes the quantity recorded in the driest year is adopted. A reduction of from 15 to 20 per cent should also be made from the total rainfall for loss by evaporation, &c.

If storage accommodation is not provided for the maximum rainfall during the wet season, it is not safe to calculate on the average amount for the year being available, as some of the water will run to waste during the wet season.

Rainfall in inches $\times$ ·52 = gallons per square foot.
1 in. of rain over 100 sq. ft. = 52 gal.
1 in. of rain over 1 acre = 22,650 gal. nearly (or about 101 tons).

A cottage measuring 20 ft. $\times$ 15 ft., with a mean annual rainfall of 25 in., will yield 3900 gal., or nearly 10·7 gal. per day throughout the year, without making any allowance for loss. With an available rainfall of (say) 17 in. during the driest year, and deducting 20 per cent for evaporation, &c., the yield would be:—

2652 gal. − 530 gal. = 2122 gal., or 5·8 gal. per day.

The table on the following page shows the daily yield of water from roofs of various sizes with varying rainfall.

**Special Collecting Areas.**—In addition to the roof surfaces, it may often be expedient to form special collecting areas, the rainfall from which is conducted into underground tanks. In the country, where land is plentiful, a portion may be set apart and specially prepared for the purpose. The area required can easily be determined from the data already given.

To guard against surface pollution by cattle or other animals, the area should be fenced in, and it should stand slightly higher than the adjoining ground, or be surrounded by a ditch to prevent the surface-water from the vicinity, which may be more or less contaminated, from having access to it.

If it is desired to keep out rabbits from the enclosed area, wire netting must be employed. The netting should not only stand a certain height above the ground, but it should also be sunk about 18 in. below the surface, and then turned outwards for about 1 ft. and the trench filled in. Rabbits would burrow underneath the vertical portion, but are stopped by the horizontal.

The gathering-ground may be either concreted over or finished with a layer of asphalt laid with a fall towards the catch-pit, from which a drain pipe would lead the collected water to the tank. The surface should be periodically cleaned from all dirt, dust, leaves, birds' droppings, &c., which may collect on it.

In some tropical countries, where the rainfall is almost the sole source of supply, these special gathering-grounds are a necessity, and great care is requisite to ensure that they are protected from all risks of pollution.

A paved surface of concrete or asphalt, exposed as described above, will

## Table showing the Daily Yield of Water from Roofs of Various Sizes with Varying Rainfall

From Tables compiled by Mr. H. Sowerby Wallis, F.M.S.[1], which are here given as originally published, but which now require some slight modification.

| Mean Rainfall. | Loss from Evaporation, &c. | Requisite Capacity of Tank. | Mean Daily Yield of Water. | Mean Daily Yield of Water. In wettest year. | Mean Daily Yield of Water. In driest year. |
|---|---|---|---|---|---|
| inches. | per cent. | cubic feet. | gallons. | gallons. | gallons. |
| | Area of house, 10 ft. × 20 ft. = 200 sq. ft. | | | | |
| 20 | 25 | 100 | 4·3 | 6·7 | 3·2 |
| 25 | 20 | 135 | 5·7 | 7·5 | 3·9 |
| 30 | 20 | 145 | 6·8 | 9·4 | 4·5 |
| 35 | 20 | 155 | 7·9 | 11·0 | 5·0 |
| 40 | 15 | 165 | 9·7 | 13·1 | 7·2 |
| 45 | 15 | 170 | 10·9 | 14·2 | 8·8 |
| | Area of house 15 ft. × 20 ft. = 300 sq. ft. | | | | |
| 20 | 25 | 150 | 6·4 | 9·9 | 4·8 |
| 25 | 20 | 200 | 8·6 | 11·3 | 5·8 |
| 30 | 20 | 225 | 10·3 | 14·2 | 6·9 |
| 35 | 20 | 235 | 12·0 | 16·7 | 7·7 |
| 40 | 15 | 245 | 14·5 | 19·6 | 10·8 |
| 45 | 15 | 250 | 16·4 | 21·4 | 13·1 |
| | Area of house 20 ft. × 25 ft. = 500 sq. ft. | | | | |
| 20 | 25 | 250 | 10·7 | 16·6 | 8·0 |
| 25 | 20 | 335 | 14·3 | 18·7 | 9·7 |
| 30 | 20 | 375 | 17·1 | 23·6 | 11·4 |
| 35 | 20 | 390 | 19·9 | 27·7 | 12·7 |
| 40 | 15 | 405 | 24·2 | 32·8 | 18·0 |
| 45 | 15 | 415 | 27·3 | 25·7 | 21·8 |
| | Area of house 20 ft. × 50 ft. = 1000 sq. ft. | | | | |
| 20 | 20 | 500 | 22·8 | 30·1 | 15·5 |
| 25 | 15 | 665 | 30·3 | 40·0 | 20·6 |
| 30 | 15 | 740 | 36·4 | 50·3 | 24·4 |
| 35 | 15 | 785 | 42·4 | 59·0 | 27·0 |
| 40 | 15 | 815 | 48·4 | 65·3 | 36·3 |
| 45 | 15 | 835 | 54·4 | 71·3 | 43·5 |
| | Area of house 25 ft. × 80 ft. = 2000 sq. ft. | | | | |
| 20 | 20 | 1010 | 45·6 | 60·2 | 31·0 |
| 25 | 15 | 1330 | 60·6 | 80·0 | 41·2 |
| 30 | 15 | 1480 | 72·7 | 100·5 | 48·7 |
| 35 | 15 | 1570 | 84·8 | 118·0 | 54·0 |
| 40 | 15 | 1630 | 96·7 | 130·6 | 72·6 |
| 45 | 15 | 1670 | 108·8 | 142·7 | 87·1 |

[1] Sanitary Institute *Transactions*, Vol. I, 1879.

yield almost the whole of the rainfall; but sometimes an excavation is made, and the concrete paving is laid below the normal level of the ground, and then covered with mould. Grass is grown on the surface, and the filtration, which takes place as the water sinks down to the hard bottom, thoroughly purifies it. Dr. Vivian Poore strongly advocated this method of collection, as the surface vegetation is a great purifier, a good close crop of grass having almost the same effect on polluted water as the jelly-like mass which forms on the surface of a properly acting sand filter.

This fact has been taken advantage of by Mr. Ware, who, to protect the outcrop of some of the doubtful gathering-grounds near Maidstone, had the space covered first with a layer of well-rammed chalk and then another of fine sand, above which was spread sufficient mould to afford nutriment for a close crop of grass. This constitutes a perfect filtering area.

**Filtration of Rainwater.**—All the rainwater collected from roofs and other gathering-grounds, and required for domestic use, should undergo some sort of filtration, to remove at least the solids held in suspension, before it is discharged into the storage tanks. Some of the sediment and other impurities washed down from the roofs may be run to waste by means of separators, or retained in the gullies or catch-pits at the foot of the stack pipes, as already explained. Specially prepared collecting-surfaces should deliver the water falling upon them into gullies or catch-pits provided with overflows leading to the tanks, and care is necessary to see that the deposit retained is periodically cleaned out; otherwise it is liable to become offensive, or may block up the outlet altogether, after permitting a quantity of the solids to pass into the tank.

All underground drains conveying rainwater for domestic use should discharge their contents into a catch-pit, the overflow from which passes through a series of layers of sand and gravel before passing into the storage tank itself, as shown in Plate XIII. This filter may be arranged either as a single or as a double filter, and the filtering materials should be periodically renewed or taken out, thoroughly washed, and replaced.

At one time a layer of charcoal was placed between the layers of sand and gravel, but this was found soon to lose its effect, and, as it favoured the growth of organisms, its use has been discontinued. It is always a difficult matter to ensure the regular inspection and cleansing of these underground filters, even when ready means of access is provided.

**Overflows and Wastes.**—Arrangements must be made for the disposal of the surplus water which may flow into the tank after it is full. Overflows or wastes are provided for this purpose, consisting of a pipe (not less in capacity than the incoming delivery pipe) led through the wall of the tank at the high-water level. The overflow may be at the extreme end of the tank, to ensure a circulation of water, or it can be arranged to lead from the catch-pit adjoining the filtering chamber, and this is frequently an advantage during heavy rains, when much dirty water is being delivered, as, when the tank is full, the surplus water would pass through this storm-water overflow without entering the tank at all.

Some authorities consider it advisable to have overflows both from the storage tank and from the filtering chamber, that from the latter being at

a somewhat higher level than the other, so as to come into operation when the water rushes in at a greater rate than it can pass through the filter.

Overflows should never be led into a foul drain unless properly disconnected from it. Where possible it is better to discharge into the open air, when it is necessary to protect the mouth of the pipe by a grating of some sort, to prevent the entry of animals. If the storm-water drainage is distinct from the foul, the overflow from the tank may discharge into one of the manholes of that system.

**Pumps.**—Wherever the underground rainwater tank may be situated in relation to the buildings to be supplied, it is usual to fix a pump at some convenient point for the purpose of raising the water. The old-fashioned method of drawing water by means of buckets dipped by hand, or lowered by means of a rope or chain from the surface, is very objectionable, especially if the water is required for domestic purposes.

The pump may be of the pillar variety, standing by itself over or close to the tank, or it may be fixed on a plank against the house wall, usually outside but sometimes within the house. The water may require to be drawn at the ground level only, or it may have to be pumped up into cisterns in the roof, to supply by gravitation the various fittings on the floors below. In the former case a suction pipe only would be required, the water being discharged at the spout of the pump, but in the latter case a lift-and-force pump would be necessary, having a delivery pipe carried up from the pump and turned over the edge of the cistern. A draw-off tap should be fixed at the pump level, so that water could be drawn direct from the delivery pipe without passing into the cistern.

The lower end of the suction pipe should dip down into the water to within a few inches of the bottom, a perforated rose or strainer being fixed at the end to prevent solid matters or sediment from being sucked up, whilst at the same time enabling almost the whole of the water contained in the tank to be utilized. Suitable pumps are shown in Plate XIII.

The suction and delivery pipes are usually about one-half the diameter of the working barrels of the pumps, which may vary from 2 in. to 4 in.; for a pump with a 3-in. barrel these pipes would be $1\frac{1}{2}$ in. diameter. They are usually of wrought-iron tubing, fitted together with screw-collar joints.

An **overflow or warning pipe** from the cistern should be provided, discharging in view of the operator at the pump. To prevent any danger of flooding, an overflow is sometimes provided of a sufficient size to allow the water to escape, when the cistern is full, as fast as it is pumped in, but it is usual to fix a warning pipe, about $\frac{3}{4}$ in. in diameter, just under the level of the larger overflow, so that it will come into operation first, and warn the operator that the cistern is full.

# CHAPTER III

## WELLS AND PUMPS

Wells are usually described as being either *surface* or *deep*.

**Surface or shallow wells** are sunk into the water-bearing subsoil only (A, fig. 247), whilst **deep wells** go down through an impervious stratum underlying this subsoil until a lower water-bearing stratum is tapped (B, fig. 247).

It is not the actual depth, therefore, to which wells are sunk which decides whether they are shallow or deep. A shallow well may go down 40 ft. or 50 ft. in one district, whilst in another the subsoil may only be 15 ft. or 20 ft. deep, with perhaps a bed of clay 10 ft. thick underneath. A well sunk through the latter may reach water immediately; and this, although only about 30 ft. in depth, would be looked on as a deep well. The usual classification of deep or shallow wells as being over or under 50 ft. in depth, respectively, is therefore misleading.

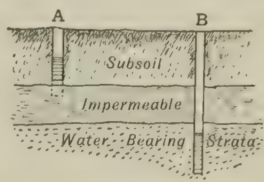


Fig. 247.—Shallow and Deep Wells

**An Artesian Well** (fig. 248) is also a deep well, but with this difference, that it taps a saucer-shaped water-bearing stratum lying between two impervious strata. The ground-water level of this pervious stratum being above the bottom of the well, the water rises in the well, and in some cases overflows, the height to which it rises depending on the relative heights of the well and of the outcrop or its ground-water level. It will be understood from fig. 248 that this saucer-shaped permeable stratum contains a subterranean reservoir, and that, if at any point within the depression a well is sunk down through the upper impermeable stratum, the water will rise in the well, and may overflow without pumping.

Fig. 248.—Artesian Well

**Quality of Well Water.**—Well water will vary in purity according to the nature of the soluble impurities in the strata through which it filters.

Shallow wells are always more or less liable to pollution from the animal or vegetable matters in or on the surface soil. A porous subsoil resting on an impervious bed retains the water sinking into it, and this water is liable to be polluted in various ways and degrees, according to the surroundings, at any particular point. The open country may yield fairly good water, but in towns, villages, or the immediate neighbourhood of farm buildings a considerable amount of polluting matter may be washed into the soil by the rain. Cesspools or cesspits with porous sides and bottoms, farmsteads with their badly paved yards, manure heaps, pig sties, and highly manured gardens, all assist in polluting the water which, first falling as rain, soaks

into the ground, and ultimately finds its way into the wells in their vicinity. Under favourable conditions the foul liquids may be partially purified by filtration on their way to the well; but these conditions do not always obtain, and there are frequent instances of sewage having direct access to wells.

If water from such doubtful wells must be used, in default of other supply, the greatest care should be taken to render the wells impervious to the entrance of water for a depth of 10 ft. to 15 ft., or more, according to the nature of the subsoil. The mouths of the wells should be raised above the level of the surrounding ground, a portion of which should be covered with impervious paving, sloping away from the well head.

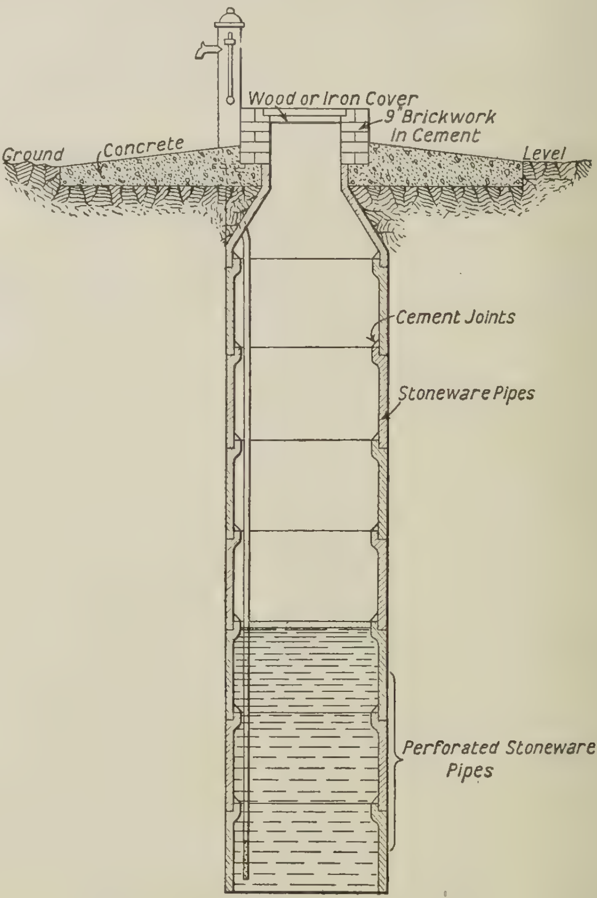



Fig. 249 A.—Well constructed with Stoneware Pipes

Whilst most waters drawn from shallow wells should be regarded with suspicion, that derived from deep wells is usually most wholesome and palatable. Although that drawn from certain strata may be more or less hard, there is seldom any organic impurity, except where fissures or faults in the overlying beds allow surface-polluted water to pass direct to the well without having undergone efficient filtration.

**The Construction of Shallow Wells.**—In many rural districts, too sparsely populated for the houses or groups of houses to be served with a public water supply, except at a prohibitive cost, the water supply must, to a great extent, depend on shallow wells. Hence the necessity for taking precautions to ensure that they are properly constructed. The following instructions are issued by the Chelmsford Rural District Council (see figs. 249 A and 249 B):—

"In the large majority of cases where shallow wells yield polluted water, it is due to defects in the construction of the wells. The following

suggestions are submitted by the Chelmsford Rural District Council, upon the advice of their officers, for the construction of such wells:—The water which enters a well at a depth of 6 ft. to 12 ft., depending upon the porosity of the soil, is usually efficiently filtered and purified. Water entering at a less depth is nearly always liable to be imperfectly purified and unsatisfactory in quality. The nearer the ground surface at which water can enter the greater the danger of pollution.

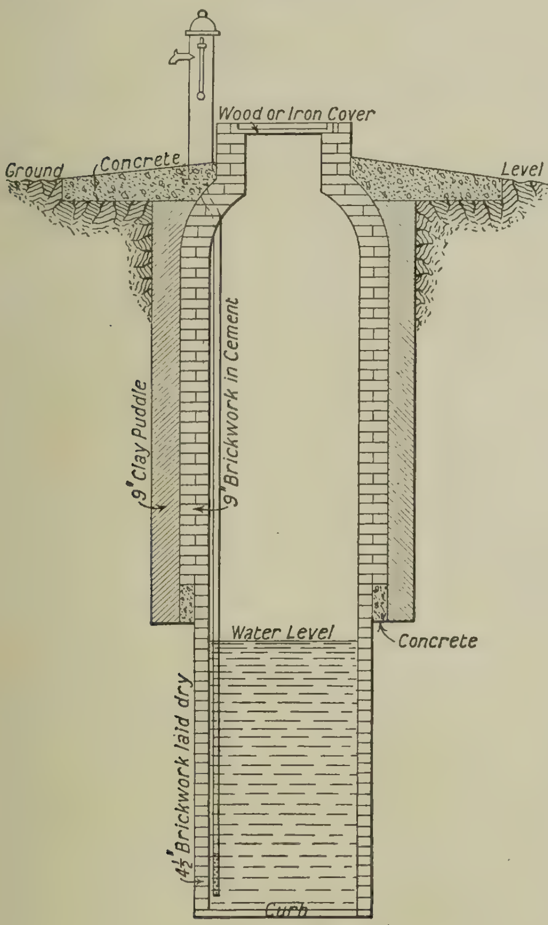


Fig. 249B.—Well steined with Brickwork

"It follows, therefore, that the upper 6 ft. to 12 ft. of the well should be water-tight, and that the top should be so finished off that no surface water can possibly gain access. It is also very desirable that the top of the well should be brought 6 in. to 12 in. above the ground-surface, and covered with a proper flagstone, or wood, or iron cover.

"Plans showing two of the simplest methods of well-construction are appended.

"As no new house can be occupied without a certificate from the sanitary authority to the effect that the house has a sufficient supply of wholesome water, it is important that builders and others should pay particular attention to the above suggestions, and so avoid the risk of a certificate being refused."

As will be seen from the figures, each well is properly protected at the surface, and made water-tight for a certain depth by cement-jointed stoneware pipes, or by brickwork in cement, with clay-puddle backing. The surface water, therefore, must travel a certain distance before it can enter the wells either through the perforations in the lower pipes or through the dry-brick lining, and consequently must undergo a certain amount of filtration.

"**Abyssinian**" **Tube Wells** consist of a series of steel tubes, the first or bottom length having a solid steel point, above which there are a series of perforations, extending about 18 in. up the tube. This length is driven into the ground by means of a weight, which is alternately raised (by

ropes and pulleys) and dropped on the top of a block clamped to the tube, and when this has been driven down to a sufficient depth, a fresh length of tube is screwed on, and the clamp refixed above the socket. This goes on until water is reached, which can be ascertained by dropping a plumb bob down the interior.

A pump is then attached, and kept going until the water (which at first appears dirty) becomes clear. As the ordinary suction pump can only be used for a depth of about 25 ft., it would be necessary for the water to rise to that level, even although the tubes might be driven to a greater depth. For a tube well $1\frac{1}{4}$ in. in diameter, a pump with a $2\frac{1}{2}$-in. barrel would be required, and a 2-in. tube would require a pump with a 3-in. barrel.

The best results are obtained when the tubes are driven into such soils as gravel, coarse sand, or loose chalk, but they are not so suitable for fine sand, marls, or clay, and they cannot be driven through or into rock. In the event of water not being found at any particular spot, they can easily be withdrawn and re-driven elsewhere.

**Bored or Tube Wells** (fig. 256) are often driven from the surface of the ground or from the bottom of dug wells in order to tap water-bearing strata at great depths. They can be driven through rock, and steel tubes are inserted for the greater part of their depth to prevent choking. Special pumps are made for bored wells (fig. 256).

**Pumps** are appliances for raising water from a lower to a higher level. The ordinary suction and lift-and-force pumps, depending as they do on the pressure of the air for their action, are sometimes described as *atmospheric pumps* to distinguish them from those of the *mechanical* type, such as centrifugal and chain pumps.

The pressure of the atmosphere at sea level is 14·73 lb. per square inch, and this is found to balance a column of water 33·9 ft. high, or a column of mercury 30 in. high, the latter being 13·6 times as dense as water. It is more easily remembered, and quite near enough for practical purposes, to consider that the pressure of the air at 15 lb. per square inch balances either a column of water 34 ft. high, or of mercury 30 in. high. Theoretically, therefore, these atmospheric pumps should draw water from depths of 34 ft., but it is found in practice that, owing to imperfect fittings, the necessary vacuum cannot be obtained to raise it more than about 28 ft. or (for satisfactory working) 25 ft.

Again, as the height above sea level increases, the atmospheric pressure becomes less, and the results will vary slightly according to the barometric pressure.

**Common Suction Pump.**—Sections of the common suction pump are shown in fig. 250. That on the left shows the piston at the bottom of its stroke ready to commence work, and the other two sections illustrate the condition of affairs during an up and a down stroke of the piston respectively, when the pump is properly at work. A is an iron or brass cylinder termed the *barrel*, in which works a water-tight piston B, attached to a rod, which is alternately raised and lowered by means of a lever handle or wheel, generally worked by hand. Connected to the lower end of the barrel is

the *suction pipe* C, which dips into the water to be raised, a valve D, termed a *suction valve,* which opens upwards, being fixed at the junction. The piston or *bucket,* as it is termed, is fitted with a leather or other *clack* valve, E, which also opens upwards.

On referring to the left-hand section, it will be seen that the bucket is at the bottom of the barrel, both valves being closed. The water level is shown at the same height inside as outside the suction pipe, indicating that the atmospheric pressure is the same.

When the bucket is raised by depression of the lever handle, a partial vacuum is formed below it, and the pressure of the air in the suction pipe forces open the valve D, and the air rushes through to fill the vacuum being formed under the rising bucket. The elastic force of the air being thus diminished, the atmospheric pressure on the water surrounding the suction pipe will cause the water to rise in the pipe until the external and internal pressures counterbalance each other. As soon as the upward motion of the bucket ceases, the valve D closes by its own weight, and during the downward stroke the valve E opens to allow the air in the lower portion of the barrel to escape. A few strokes are sufficient to exhaust the air, its place being taken by the water, which, rising through D on the up stroke, and then through E on the down stroke, is ultimately discharged at the spout or nozzle.

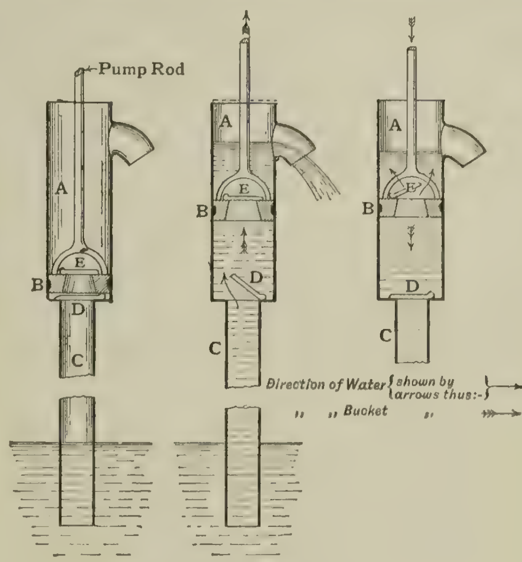



Fig. 250.—Common Suction Pump

The centre section in fig. 250 shows the bucket during its up stroke, lifting the water above it to the point of delivery, the space below being filled by the water rising through the valve D. During the down stroke, as shown in the third section, the valve D remains closed, retaining all the water which had passed through during the previous up stroke, and which now passes through the bucket valve E, to be in its turn lifted for discharge at the next up stroke.

**Suction-and-Lift Pumps.**—When the water is required to be delivered at a higher level, say into a cistern on an upper floor, another pipe, termed a *rising* or *delivery pipe,* is attached to the upper end of the barrel (fig. 251) instead of the spout or nozzle. In this case the barrel must have a close cover, the piston rod working through a water-tight stuffing-box to prevent leakage. The two views represent what takes place during the upward and the downward stroke of the bucket respectively.

On commencing pumping, a few strokes will exhaust the air from the suction pipe and from the lower portion of the pump barrel, from which it escapes up the delivery pipe, the water which gradually rises to take its place being forced up by the atmospheric pressure on the surface of that surrounding the suction pipe at its lower end. The water passes through the suction valve D during the up strokes, and through the bucket valves E during the down strokes. In each case the water is prevented from falling back by the alternate closing of the valves D and E, and it is ultimately lifted up the delivery pipe by the upward strokes.

The left-hand illustration in fig. 251 shows a *foot valve* and *strainer* attached to the lower end of the suction pipe. The combined area of the holes in the strainer should be nearly double the area of the suction pipe.

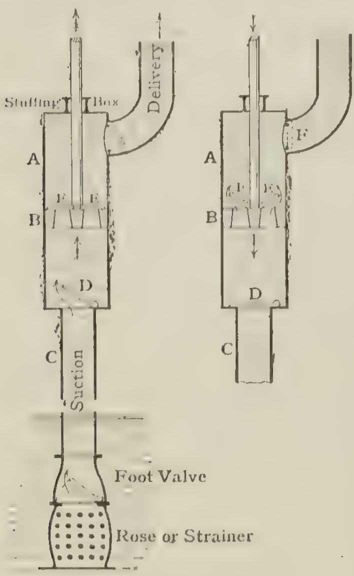


Fig. 251.—Suction-and-Lift Pump

When the suction pipe is long, or the height of the delivery pipe exceeds (say) 15 ft., an air vessel should be fixed close to the pump to reduce the concussion between the suction valve and the column of water which is being raised. It is also desirable that a valve should be fixed at the foot of the delivery pipe, as shown by dotted lines at F, which by closing on the commencement of the down stroke relieves the piston valves and stuffing-box from the pressure due to the height of the column of water in the delivery pipe.

**Suction - and - Force Pumps.** — Another method of raising water is by means of suction-and-force pumps, so called because they first raise the water for a certain height by suction, as already described, and then force it upwards or onwards as required, by solid pistons or plungers. A, fig. 252, shows a solid piston, and B the plunger or ram arrangement, the principle being almost the same in each case.

On the up stroke of the piston or plunger, the air below is gradually exhausted, the water rising through the suction valve D to take its place. On the down stroke the valve D closes, and that at F opens, allowing the water to be forced up the delivery pipe until the piston or plunger has reached the bottom of its stroke. On the up stroke commencing, the valve F closes (preventing the return of water in the delivery pipe) and the valve D opens, to admit the water from the suction pipe into the barrel.

Except on the score of cleanliness, it is immaterial to the working whether the top of the piston pump barrel (A, fig. 252) is covered or not, but it is necessary that the plunger should work through a properly formed water-tight stuffing-box to prevent leakage. The packing of these stuffing-boxes is usually of plaited hemp gasket, moistened with oil or steeped in boiling tallow. That for the plunger can readily be renewed in position,

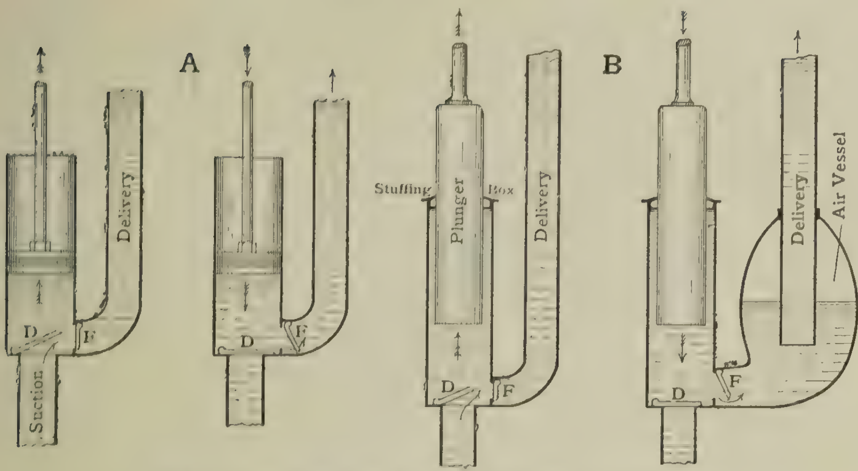



Fig. 252.—Suction-and-Force Pumps. A, with Piston; B, with Plunger

whereas the piston requires to be withdrawn from the barrel for treatment.

**Air Vessels.**—To do away with the shocks caused by the sudden starting and stopping of the columns of water in the suction and delivery pipes at each stroke of the piston or plunger, *air vessels* are used. They should be fixed at the foot of the delivery pipe, close to the barrel, somewhat as shown on the right-hand section in fig. 252. During the descent of the plunger the water is forced into the air vessel and up the delivery pipe, the air in the upper portion of the air vessel being compressed. On the ascent of the plunger the valve F closes, and the compressed air, in expanding to its original bulk, tends to force the water up the delivery pipe until augmented by the next down stroke.

When there is no air vessel, on the completion of the down stroke the column of water in the rising main comes to rest until the propelling force is again applied at the next down stroke, the action being thus intermittent and jerky. Owing to the elasticity of the compressed air in the air chamber, however, the onward movement of the water is maintained, the delivery being more or less continuous, and the objectionable concussion greatly diminished.

**Single-acting Pumps.**—On referring to the figures of the pumps described, it will be seen that they are all *single-acting*—that is to say, the water is discharged either on the up or on the down stroke, but not on both. In the suction-and-lift pumps, figs. 250 and 251, water is discharged during the up strokes, whilst with the suction-and-force pumps (fig. 252), the discharge is during the down strokes.

A single-acting pump provides a more or less intermittent flow, and, when the pressure is great, works irregularly, owing to nearly the whole of the power being exerted during either the up or the down stroke. For more steady working two barrels are better, but the best results are obtained with a combination of three pumps, driven by a three-throw crank, the throws being at an angle of 120° to each other.

**Double-acting Lift-and-Force Pump.**—Fig. 253 shows a double-acting lift-and-force pump, by which water is admitted into the barrel from the suction pipe at one side of the piston, whilst it is being forced up the delivery pipe from the other side, at each stroke.

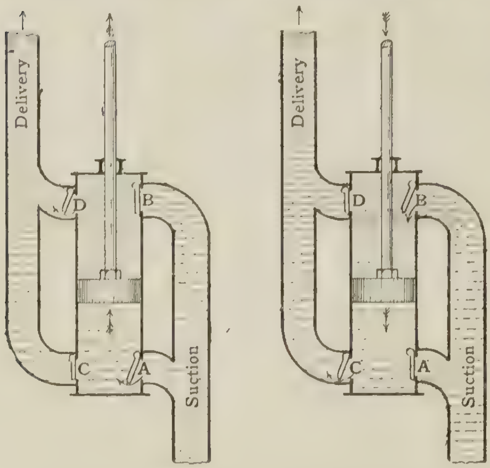


Fig. 253.—Double-acting Lift-and-Force Pumps

As will be seen from the figures, all the valves open to the left, A and B from the suction pipe, and C and D into the delivery pipe. Valves A and D are open during the up stroke, admitting water from the suction pipe at A, and into the delivery pipe at D; valves B and C remaining closed. When the piston begins to descend, valves A and D close, and B and C open. There is thus a constant and uniform delivery of water.

**"Lift" and "Force" Defined.**—The term "lift", as applied to pumps, is sometimes rather loosely used. It should be understood that in all the pumps described the water is raised by suction until it either passes through the piston valve E on the down stroke (figs. 250 and 251), or the suction valve D (fig. 252). Above this point the water is either "lifted", it may be only for a short distance, to the spout, as in fig. 250, or to any higher level, as in fig. 251, or it may be "forced" to this higher level by a solid piston or plunger, as in fig. 252.

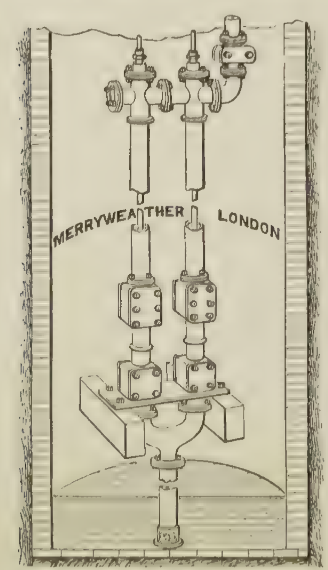


Fig. 254.—Stand Pipes on Pump Barrels and Access Doors to Valves

The double-acting lift-and-force pump, shown in fig. 253, also draws water by suction through the valves A and B into the barrel, from which it is either "lifted" or "forced" up the delivery pipe according to the direction of the stroke. Hence it may be termed a combined suction-lift-and-force pump.

**Position of Pump Barrels.**—Ordinary suction pumps fixed at the ground level are only available for raising water from depths not exceeding 28 ft. Usually from 20 to 25 ft. is considered a more practical depth to ensure satisfactory results. When the surface of the water exceeds these limits in depth, the pump barrels should be fixed down in the well itself within reasonable suction distance of the water, or they may even be under water at times, the motive power being applied from the surface by means of rods connected

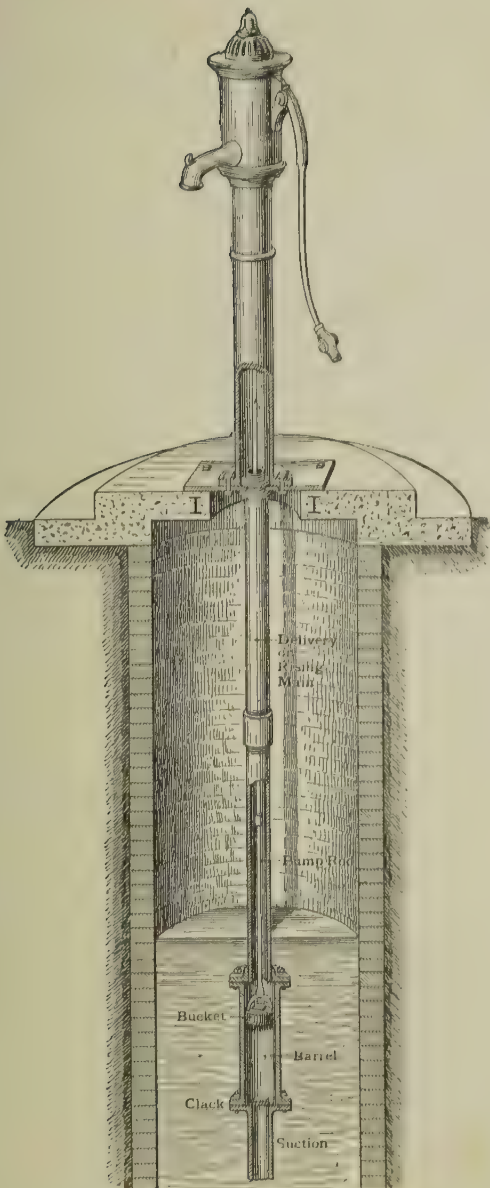
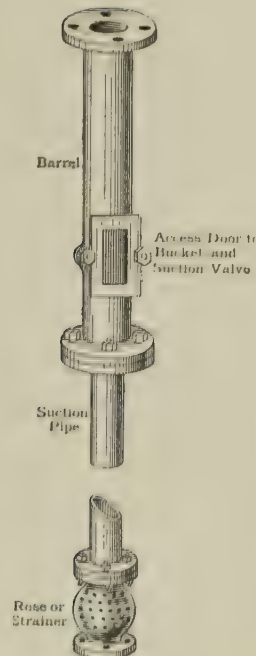



Fig. 255.—Tylor's Artesian Pumping Apparatus




to the pistons, and kept truly vertical by roller or other guides at intervals (fig. 256). The rising main or delivery pipe also requires support, and occasionally the pump rods are arranged to work within this pipe (figs. 255 and 257). When supported at the ground level, as shown in fig. 255, the whole apparatus must be withdrawn when any repairs are required.

In cases where the water level in the wells fluctuates considerably, arrangements must be made for the withdrawal of the working parts of the pump for examination, renewal, or repairs, without having to lower the water level by pumping when the barrels happen to be submerged. This can be done by attaching stand pipes or false barrels (fig. 254) to the barrels, and prolonging them up above the highest water level to a platform or staging, from which the necessary work can be carried

out. The stuffing-box cover would be fixed on the top of the stand pipe instead of on the barrel, and the diameter of the stand pipe should be slightly greater than that of the barrel, to enable the bucket and sucker fittings to be readily withdrawn or replaced.

When the pump barrels, whether single, double, or treble, are fixed in positions readily accessible, those having access or side doors should be provided, to enable the fittings to be got at without having to withdraw them through the top (figs. 254, 255, 256, and 270).

Messrs. J. Tylor & Sons' **Artesian Pumping Apparatus** for bored and dug wells (fig. 255), which requires no descent of well in fixing, consists of an ordinary pillar pump having a flange at the bottom for bolting to a cast-iron supporting plate. The tubes and rods are connected at the top and lowered into the well or bore hole until the required depth is reached. The suction and delivery pipes are shown as being of equal diameter, but the delivery pipe is sometimes made rather larger than the barrel, so that the bucket can be easily withdrawn through it. The stroke is 8 in., and the following table shows the capacities of the various sizes:—

| | | | | |
|---|---|---|---|---|
| Internal diameter, in inches, of pump barrel ... | $2\frac{1}{2}$ | 3 | $3\frac{1}{2}$ | 4 |
| Internal diameter, in inches, of suction and delivery pipes ... ... ... ... | 2 | 2 | $2\frac{1}{4}$ | $2\frac{1}{4}$ |
| Quantity in gallons raised per hour, if worked 25 full strokes per minute ... ... | 215 | 318 | 418 | 546 |
| Maximum vertical height in feet to which one man can raise the above quantities ... | 60 | 40 | 30 | 20 |

The **Double-throw Pumping Apparatus** shown in fig. 256 can be worked by one or two men, and has a capacity practically double that of the pillar pump last mentioned when worked by one man only. With two men at work, the vertical height to which the water can be raised is also doubled.

Fig. 257 shows another form of Messrs. J. Tylor & Sons' **bore-hole pumping apparatus**, having a well engine frame for manual labour, but top gear for steam power can be substituted if desired (A). It consists of a cast-iron pump head, with gun-metal stuffing-box, copper rod and air vessel for the rising main, and gun-metal working barrel with taper box and suction valve arranged to withdraw at the surface.

**Common Suction Pump Barrel.**—The internal fittings of a common suction pump barrel consist of a *bucket* and *sucker box.* The bucket is attached to the pump rod, and is raised and lowered by a lever handle or wheel, each alternate movement forming a "stroke", the length of which is rather less than the length of the barrel. The sucker box is fixed at the junction of the barrel with the suction pipe.

In the earlier forms these fittings were of wood, the openings in them being covered with pieces of ordinary sole leather, so secured at one edge that they readily opened upwards, as on a hinge, by the pressure of the air or water from below, but fell back on their seatings again, and

so closed the openings, when the pressure was taken off. Many fittings of this pattern are still in use.

**Bucket.**—Fig. 258 gives details of a brass pump bucket complete, showing the method of attaching the pump rod, and with leather cup and clack valves. The leather clack is screwed down at one edge, which forms a hinge, allowing it to open upwards by pressure from below, as shown by dotted lines on the section. It is stiffened and weighted by means of sheet lead or other material on the upper and sometimes on the lower side as well, as shown, but care must be taken that the under piece does not prevent the leather from beating fairly on its seating.

The **cup leathers** are stamped in suitable moulds by screw or hydraulic pressure out of the best oil-dressed leather, after having been steeped in warm water, and the edges are bevelled off. The pressure of the leathers against the internal faces of the barrels (which should be truly turned and bored), whilst allowing free movement for the strokes, renders them absolutely air- and water-tight.

A brass **sucker box** is shown in detail in fig. 259, the clack being similar to that in the bucket. It is fixed in the taper tail piece connecting the suction pipe to the barrel, and can be readily lifted out for renewal or repairs by means of a hooked rod let down from the top. The valve seat is conical, and is fitted into its recess with rope packing, and not with cementing material.

**Valves.**—An improved form of valve, suitable for larger orifices and higher pressures, is formed of vulcanized india-rubber, beating on a metal grid or grating, as shown in fig. 260. If rectangular in plan, the india-rubber would be secured at one edge or along the centre, but if circular, it would be retained in position by a central bolt securing it to the grating below, and carrying a curved guard above to prevent it from opening

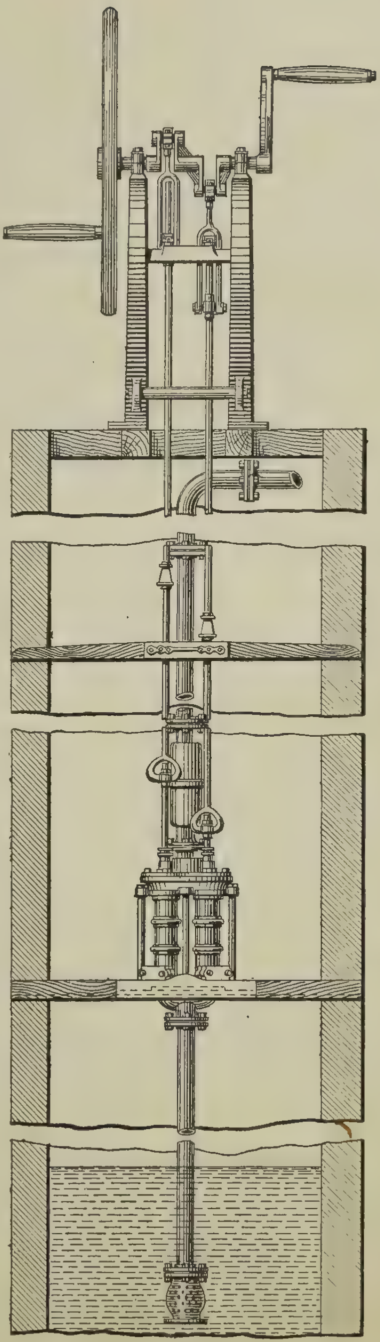
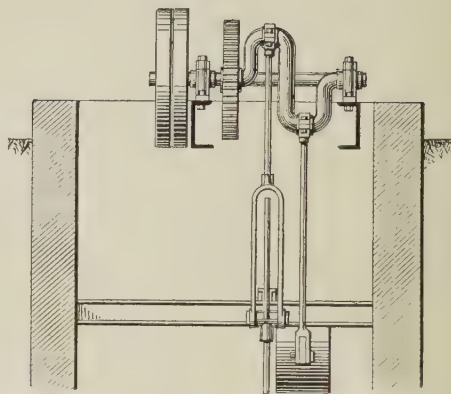


Fig. 256.—Double-throw Pumping Apparatus

A



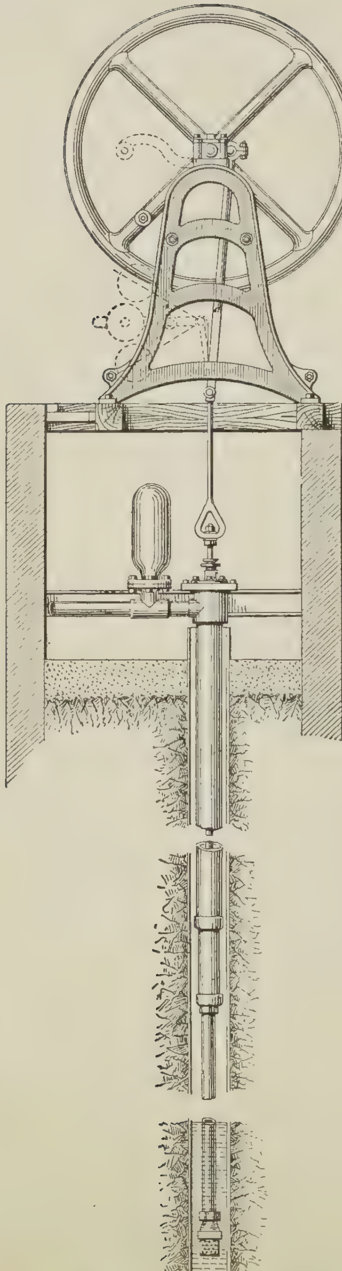


Fig. 257.—Bore-hole Pumping Apparatus

too far. In the plan the india-rubber is omitted, also one-half of the guard. The openings in the grating should be ample for the passage of the water, and the upper edges should be slightly rounded to prevent them from cutting the material when the pressure is high.

**Mushroom Valves.**—Metallic valves of the mushroom pattern are also used (fig. 261). They consist of a metallic disc, with a central spindle working in a guide, and provided with a stop to limit the rise. The rise of the valve should not exceed one-fourth its diameter, and the bearing surfaces should be narrow, from $\frac{1}{16}$ in. to $\frac{3}{16}$ in., according to the size and pressure. The bearings being conical (at about an angle of 45°), these valves are sometimes termed *conical disc valves.*

Instead of a central spindle and guide, the valve is occasionally formed with three or four wings, which bear against the sides of the valve chamber and keep the valve in position as it rises and falls. To ensure smooth working, this form of valve should only be used for moderate openings, owing to the heavy fall of the larger sizes.

**Ball Valves**, as shown in fig. 262, consist of a ball of metal, gutta percha, or vulcanized india-rubber, retained in position by a guard or cage over a seating bored to suit the size of the ball, and of a width similar to that of the mushroom valve seating. The rise should not exceed $\frac{1}{4}$ in. This form of valve is suitable for a small, fast-running pump.

**Double-beat Valves** are more complicated in their action, and are required to lessen the pressure on the bearing faces when the area of the water-way is increased.

**Glands or Stuffing-boxes** (fig. 263) are required for permitting the pump rods or plungers to work

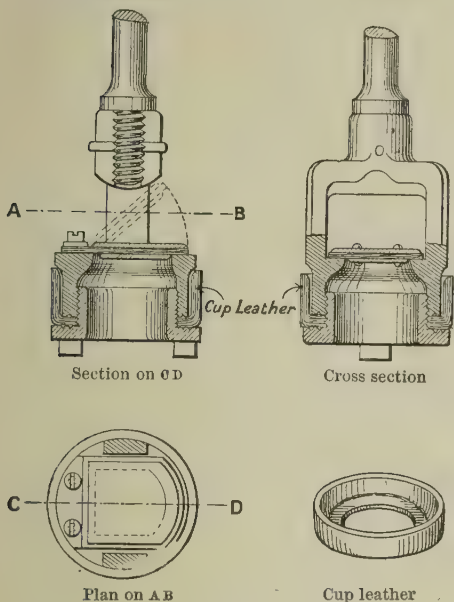


Fig. 258.—Pump Bucket Details

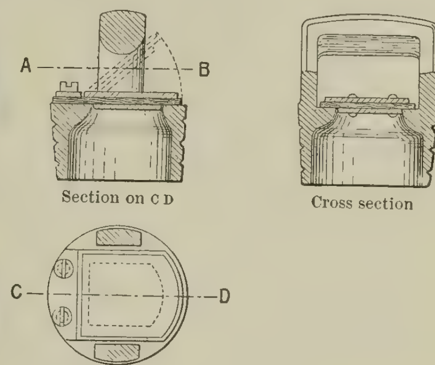


Fig. 259.—Sucker Box

freely through the covers of the barrels without leakage due to internal pressure. The annular space formed round the stuffing-box portion of the cover is packed with flax, hemp, or spun yarn moistened with oil. This packing is kept in position and compressed by a gland (either by means

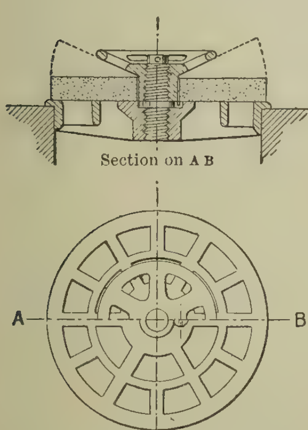


Fig. 260.—India-rubber Grid Valve

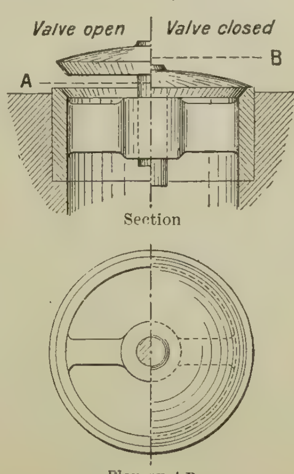


Fig. 261.—Mushroom Valve

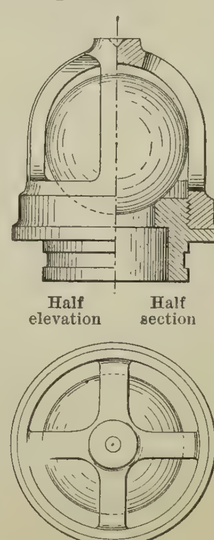


Fig. 262.—Ball Valve

of bolts as shown, or by screw threads cut in the stuffing-box and gland). Metallic packings are now often used, such as Beldam's "Pilot", Walker's "Lion", the "Dexine", the "Princeps", and Duval's.

Some authorities consider that tallow should not be used in the packing of pump glands, nor for the lubrication of the bucket rod or plunger. The pump rods working in guide rollers for deep wells should, however, be lubricated with tallow. They should be frequently examined to see that they are working freely, and all surplus oil or grease should be wiped off daily.

**Cup, neck, or hat leathers** (fig. 258) are used in lieu of the packing before mentioned. They depend for their action on the water pressure forcing them against the sliding surfaces and rendering them almost absolutely tight against the greatest pressures; hence their advantage over the ordinary packing. The edge of the cup leather should be neatly bevelled off all round, and it should work easily in the bucket when wet, without causing undue friction.

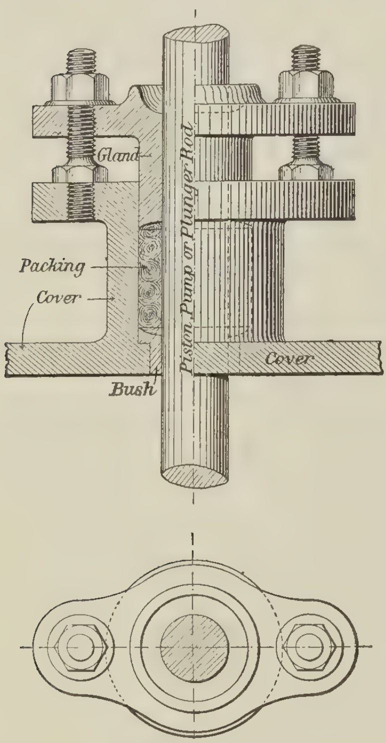


Fig. 263.—Glands or Stuffing-boxes

**The capacity of pumps** should be tested occasionally, by measuring the volume of water delivered per hour or for any other period, when working at a given number of revolutions or strokes per minute. If the discharge is considered insufficient, the fittings should be examined to ascertain whether the bucket, valves, and pipes are tight, that there is no leakage of air between the water and the pump, and whether the strainer requires cleaning.

**The "Ashley" pump** (fig. 264) made by Messrs. Glenfield & Kennedy was introduced about the year 1897, and possesses some novel features. It is now in use at a number of water works, including Brighton, Chelmsford, Cirencester, Nottingham, and other towns. The makers claim for it "perfect accessibility to, and improved arrangement of, working parts, resulting in freedom from breakdown and expensive repairs; high speed (50 to 100 per cent faster than that of the ordinary bucket and bottom-valve pump); quiet running, and great durability". The bottom valve of the ordinary pump is replaced by a number of small suction valves, of which a detailed section is given in No. 3, fig. 264. These suction valves are placed in the sides of the bucket or piston (Nos. 1 and 2, fig. 264), which slides up and down in the working barrel in the ordinary way. The delivery valves are also mounted in the bucket, and the rising main is of such a size that the bucket with its delivery and suction valves can be withdrawn for repairs. The illustrations show one variety only of these pumps.

**Centrifugal pumps** are very useful for raising large volumes of water to a considerable height when the suction does not exceed 15 ft., and where economy and simplicity are of more importance than efficiency. There being no valves to get out of order, they are found particularly suitable for raising water containing solids in suspension; hence they are most useful in clearing excavations, drainage works, or sewage. They are very simple and compact, requiring few repairs and very little attention whilst at work.

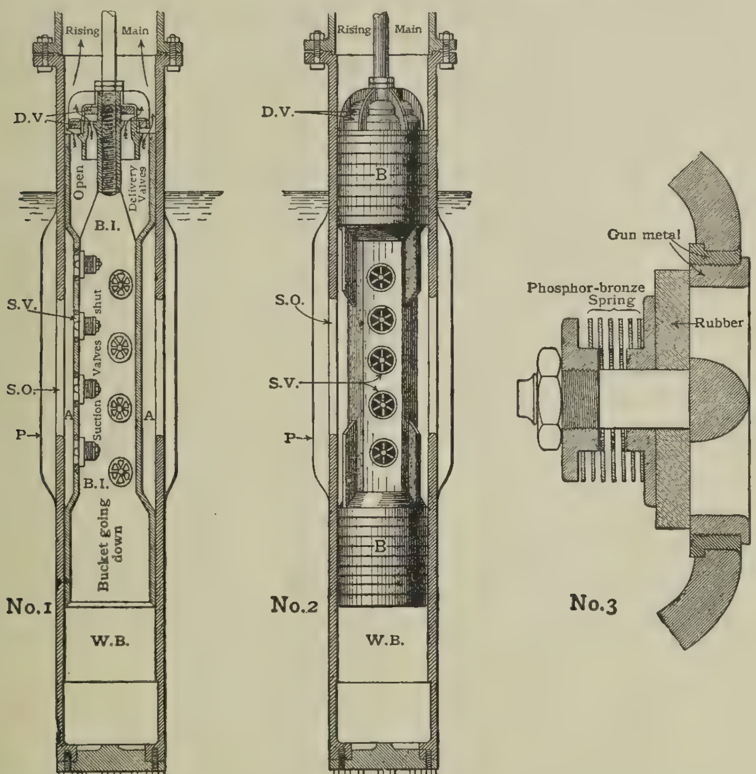



Fig. 264.—The "Ashley" Pump

No. 1, Section of working barrel and bucket; No. 2, section of working barrel and elevation of bucket; No. 3, enlarged section of suction valve; A A, "waist"; B and B1, bucket; D V, delivery valves; P, ribs; S O, suction openings; S V, suction valves; W B, working barrel.

A wheel or fan called the "impeller", having a series of curved blades, is caused to revolve rapidly in a case, creating a vacuum and drawing water by suction at the bottom and forcing it up the delivery pipe at the top by centrifugal force. There are several varieties, the fans being either single or double inlet. The latter is more perfectly balanced, as the water flows in from both sides; hence the impeller is in equilibrium, all unnecessary friction being avoided. Velocities of about 8 ft. per second in the fan and passages, and from 6 to 7 ft. in the suction and delivery pipes, are considered to give the best results, but the velocity in both pipes may vary from 6 to 9 ft. The fan may be made to revolve vertically, horizontally, or at any angle, and in some patterns a swivel arrangement enables the pump

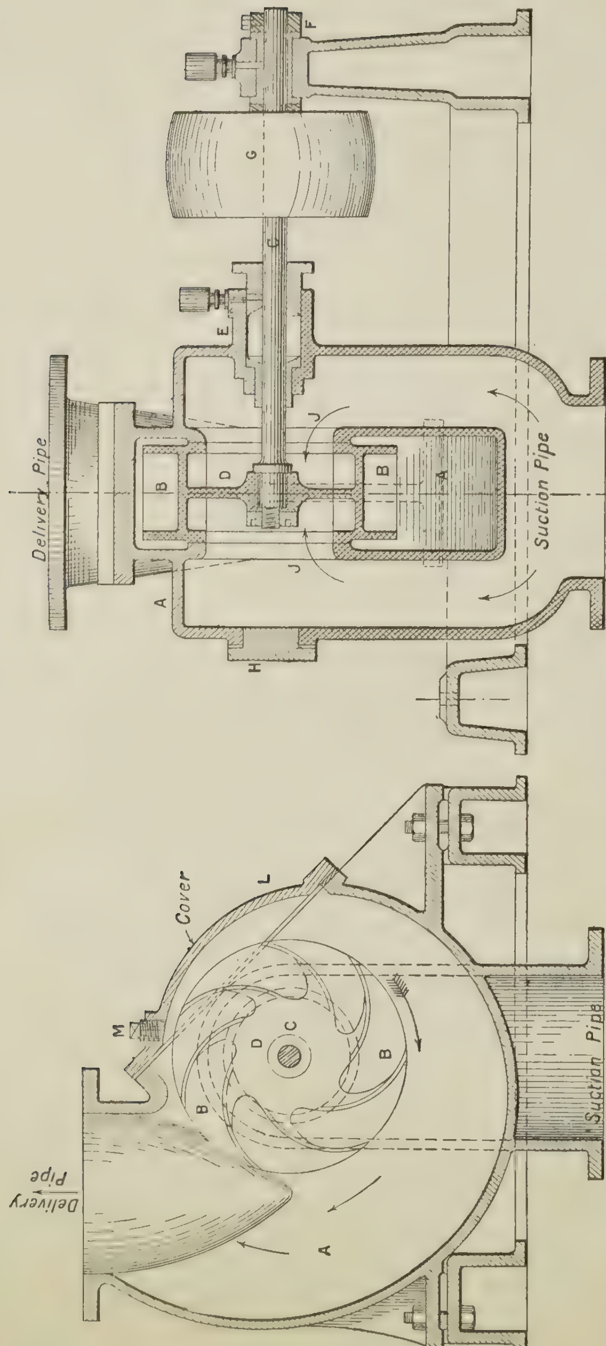



Fig. 265.—Centrifugal Pump

to be turned to any desired angle to suit the directions of the suction and delivery pipes.

Fig. 265 gives sections through an old type of centrifugal pump having a horizontal spindle, on which is keyed a pulley G, driven by belting from the fly-wheel of a stationary or portable steam-engine. The spindle C is supported at the outer end by the bearing F, whilst its other end passes into the cast-iron case A, through the gland E to the diaphragm D, where the fan B is fixed. In the cast-iron casing A revolves the fan B, with its seven curved blades contained between the parallel discs or rings. The water, as it is drawn through the suction pipe, divides right and left and enters at the centre of the fan on each side at J J, where it is caught by the curved blades, and forced up the delivery pipe.

The fan can be taken out for examination or repair without disturbing the suction or delivery pipe, by unscrewing the nut at the end of the spindle, and with-

drawing the spindle far enough to admit of the fan being taken out at the opening left by the removal of the cover L. Access to the nut at the inner end of the spindle is by the cover at H. M is an opening closed by a plug through which the pump is charged when required.

**In the modern type** of centrifugal pump the side plates are made removable, enabling the interior to be inspected without disconnecting the joints. As the pump cannot be started until the suction pipe and fan are full of water, a foot valve is necessary if the fan is fixed above the level of the water to be raised, but this is not required, where vertical-spindle pumps are used, if the fans are fixed below the lowest water level. The pump can, however, at a small extra cost, be fitted with an injector and clack valve for charging the pump, dispensing with a foot valve and the necessity of charging by hand. They may be driven by belt or electric motor as desired.

**A plain leather valve**, beating on a cast-iron face or seating, usually forms the foot valve, to which also the strainer is attached.

The **Worthington turbine multi-stage centrifugal pump** with a suction lift not exceeding 12 ft. will force water to heights ranging up to 2000 ft. This result is achieved by connecting a number of the pumps in series on the same shaft, the water being passed on with increasing velocity from the diffusion vanes of one impeller into the suction opening of the next, and so on until the necessary delivery pressure is obtained. The peculiar form of the diffusion vanes tends to convert the velocity head into static pressure with the minimum frictional loss. As these pumps require to be run at a high rate of speed, the fast-running electric motors provide suitable power. The pump and motor can be conveniently mounted on the same bed plate with their shafts in line, and connected by a flexible coupling.

**Good centrifugal pumps** have an efficiency of from 50 to 60 per cent. They will work under variable levels, and without much change of speed will absorb all the power of the engine, delivering more water as the lift decreases. The whole apparatus should be firmly secured to a suitable foundation, as there is a considerable strain from the belting which drives it.

**Rotary and Semi-rotary Pumps.**—Other pumps suitable for domestic purposes are those of the rotary and semi-rotary type. Fig. 266 shows one of Tylor's rotary pumps which have suction pipes of $1\frac{1}{4}$ in., $1\frac{1}{2}$ in., and 2 in., and delivery pipes of 1 in., $1\frac{1}{4}$ in., and 2 in. diameter.

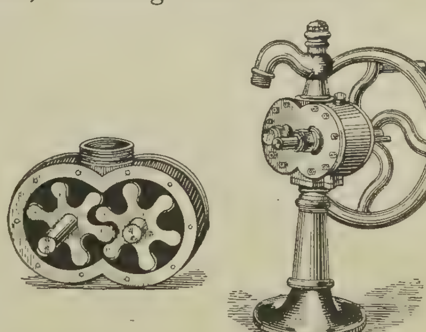


Fig. 266.—J. Tylor & Sons' Rotary Pump

Fig. 267 shows the "Perfecta" piston pump manufactured by The George Fischer Steel and Iron Works, Ltd. This pump is semi-rotary, and has a single cylinder with a double-acting suction and delivery plunger working with a very short stroke. The piston is actuated by a crank arm attached to a driving or working lever spindle, which is moved backwards and forwards by hand. The suction valves work in a detachable chamber

below the cylinder, and the delivery valves, being fixed in the top of the piston, allow a discharge into the delivery pipe at each stroke.

The pumps have a suction capacity up to 20 ft. if provided with a foot valve, and a forcing capacity of 85 ft. if an air chamber is attached. They are made in various sizes from $2\frac{1}{4}$ in. diameter of cylinder with $\frac{1}{2}$-in. delivery pipe giving $4\frac{1}{2}$ gal. per minute, up to $7\frac{1}{2}$ in. diameter of cylinder with 3-in. delivery pipe giving 70 gal. per minute. They can be provided

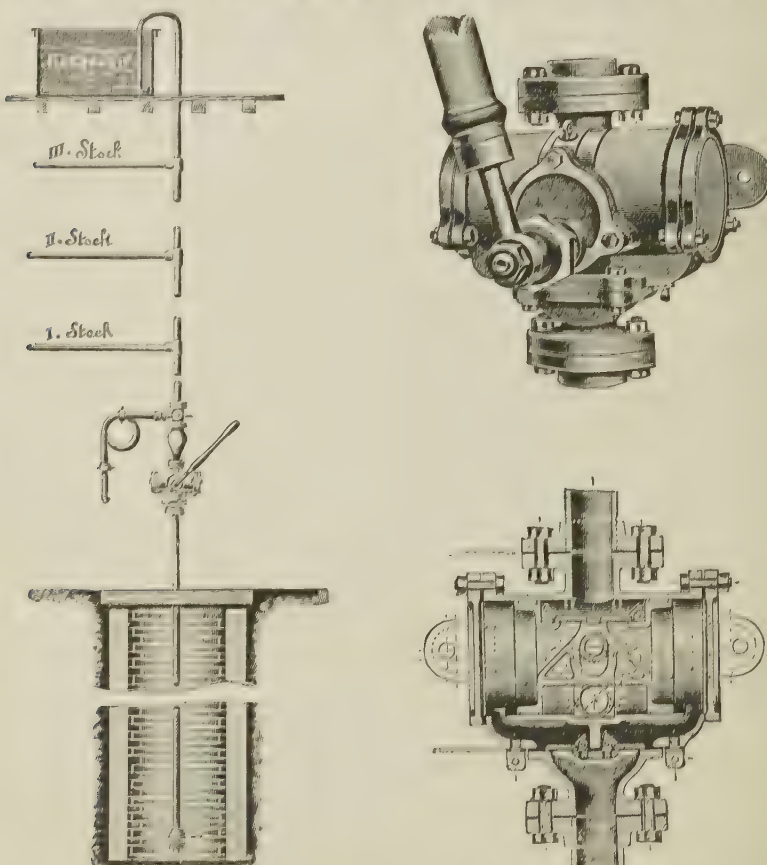



Fig. 267.—The "Perfecta" Semi-Rotary Piston Pump

with a special composition-lined cylinder to resist excessive wear and tear when belt-driven.

**Suction and delivery pipes** for pumps are usually of cast or wrought iron, but sometimes of lead or copper. Suction pipes should be as short and direct as possible, avoiding bends where practicable. If many bends are necessary, the size of the suction pipe may have to be increased. Delivery pipes should also be as direct as possible, and the bends, where necessary, should be easy, so as to reduce friction, and non-return or check valves should as a rule be fixed on them close to the pump. Except in

the case of centrifugal pumps, the velocity in small suction and delivery pipes should not exceed 2 ft. per second, or 4 ft. in large pipes.

**Cast-iron pipes** are generally flanged (fig. 256), with faced joints, and are bolted together, suitable ring washers of gutta percha, india-rubber, &c., being used to secure water-tight joints. Up to $2\frac{1}{2}$ in. in diameter they are obtainable in 6-ft. lengths, and over $2\frac{1}{2}$ in. in 6- or 9-ft. lengths. Ordinary strong cast-iron socket-jointed pipes may also be used (fig. 270), but being heavy they should be properly supported in the well where fixed vertically.

**Wrought-iron tubes**, either black or galvanized, are frequently used, especially for the smaller sizes, and are put together with screw-collar

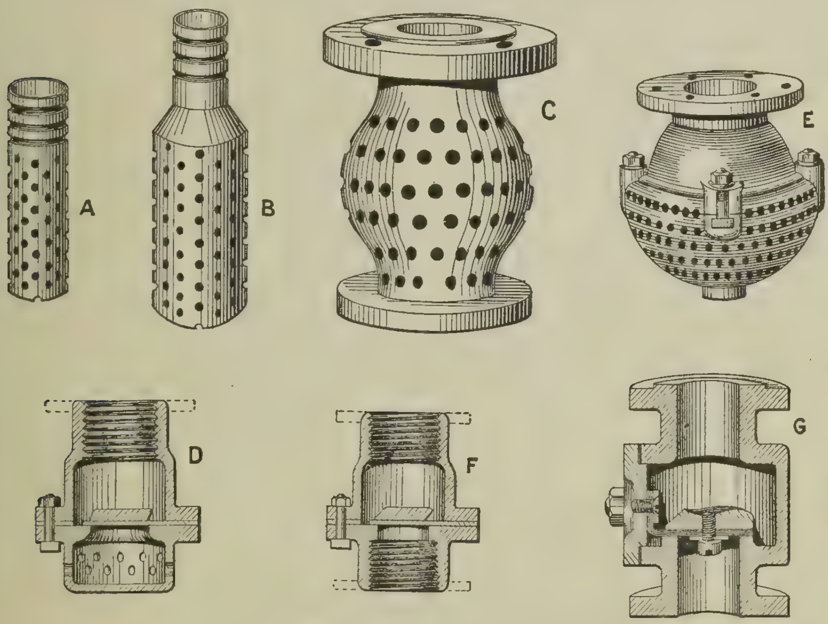



Fig. 268.—Strainers, Foot Valves, and Check Valves

joints. Pipes up to 2 in. in diameter are butt-welded; larger sizes are lap-welded.

**Lead pipes**, either of light, medium, or strong quality, are also frequently used for suction and delivery pipes when they are not likely to affect the water injuriously. They can easily be bent in any direction, while special bends or elbows, &c., are necessary with cast- or wrought-iron pipes.

**Strong brazed copper pipes**, tinned inside, are sometimes used. They are put together by means of connecting flanges with bolts, nuts, and leather washers.

**Strainers.**—The lower ends of the suction pipes should be provided with some means of preventing the solid matters or sediment from being drawn up. The lower length, or an enlargement of it, may have a series of perforations which should have a total area in excess of the bore of the pipe, but the more usual custom is to provide a special perforated casting

furnished with flanges or screw threads for attachment to the suction pipe, or to the foot valve (see figs. 251, 255, 256, and 257). These strainers may be of galvanized steel, wrought iron, or copper, and with straight or enlarged bodies (A, B, and C, fig. 268), or they may be combined with the foot valves (as at D and E).

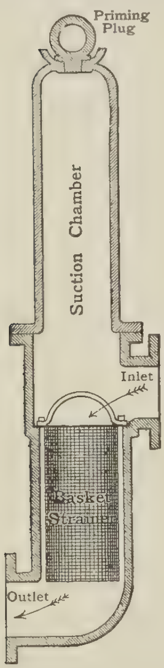


Fig. 269.—Knowles's Side Pipe and Strainer

**Foot Valves** (D and E, fig. 268) are required at the feet of long suction pipes, to prevent the return of the water. They open upwards with the suction as the water passes up, but close again when the suction ceases, and retain the water which has passed through.

**Retaining or Check Valves** (F and G, fig. 268), for fixing on suction or delivery pipes, are of a similar pattern. They can be obtained with either flanged or screwed ends, for connecting to cast- or wrought-iron pipes, and with or without side openings with covers for giving access to the valves. Those with side openings (as at G), although more expensive, are preferable.

**Knowles's Side Pipe and Strainer** (fig. 269), with or without suction chamber, is an improvement on the ordinary pattern, from the ease with which the basket strainer can be removed for cleaning out. It should be fixed close to the pump, where it is more readily accessible than when fixed on the extreme end of the suction pipe. With long suction pipes it is sometimes necessary to charge the pump with water, and this can be done by removing the priming plug at the top of the suction chamber.

# CHAPTER IV

## MOTIVE POWER FOR PUMPS

**Cost of Various Powers.**—Messrs. Merryweather & Sons, in their valuable little work on *Water-supply to Estates and Villages*, give some very useful information on the economy of substituting modern machinery and appliances for the raising of water, for some of the old types of steam engines driven by boilers wasteful of fuel. They also direct attention to the extravagance of hand labour and animal power when employed for pumping purposes, as compared with the economy of using an oil engine, or an electric motor driven from the electric-light plant when such is available, and give a comparison of the cost of pumping 1000 gal. of water to a height of 100 ft. by various powers:—

| | |
|---|---|
| 1. Hand labour, with wages at 18*s.* per week ... ... ... | 26·5*d.* |
| 2. Horse power, man at 18*s.* per week ... ... ... ... | 4·20*d.* |
| 3. Gas engine and pump, with gas at 4*s.* per 1000 cubic ft. ... | 1·44*d.* |
| 4. Small steam pump and boiler, with coal at £1 per ton . . | ·75*d.* |
| 5. Oil engine and pump, with oil at 7*d.* per gallon ... ... | ·70*d.* |
| 6. Electrically driven pump, in connection with a large steam plant for electric lighting ... ... ... ... | ·45*d.* |

The cost of attendance is excluded from Nos. 3, 4, 5, and 6, as in some instances it may be negligible, although in No. 4 an allowance should be made, varying in amount according to circumstances.[1]

For large establishments in town or country, when a good private water supply can be obtained by sinking wells or boring to a reasonable depth, the ultimate saving may be considerable in comparison with a public water supply.

**Manual labour** is, of course, often the only means available for raising water, and it can be utilized in a variety of ways. The old-fashioned method of using buckets, raised or lowered by means of ropes or chains worked by a windlass, is objectionable from the fact that the mouths of the wells are usually in a more or less unprotected condition, allowing all sorts of impurities to have access to the well. Pumps of various patterns are more frequently employed, and, whether they are to be worked by a lever or wheel, should be properly proportioned to the work required of them. If they are too large, they entail extra strain on the man pumping, and if too small, time is wasted over the work.

With the ordinary suction pump drawing water from a shallow well or tank a lever handle is usually employed, but when double or treble barrel pumps are to be used, some gearing arrangement should be adopted to enable more than one man to operate.

**Animal power.**—When animal power is available for raising water from deep wells, various arrangements of levers and gearing are employed, being made suitable for working by horse, mule, bullock, pony, or donkey. Iron covers for the protection of the gearing are useful. Fig. 270 shows Tylor's horse-gear three-throw pump, which is capable of raising from 380 gal. to 5520 gal. per hour, and which can be driven by from one to four animals, according to the power required.

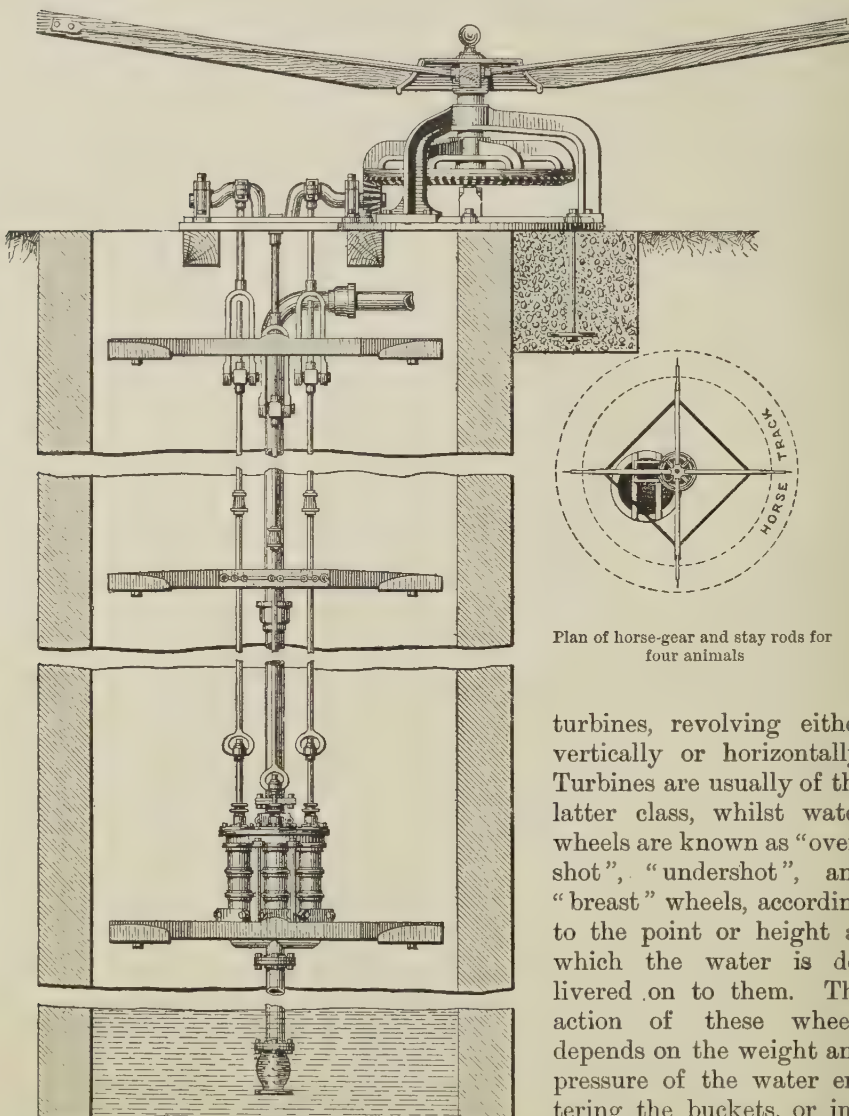
| | 8-in. stroke. | | | | 12-in. stroke. | |
|---|---|---|---|---|---|---|
| Diameter of barrel in inches | $2\frac{1}{2}$ | 3 | $3\frac{1}{2}$ | 4 | 5 | 6 |
| Diameter of suction pipe and rising main in inches | 2 | 2 | $2\frac{1}{2}$ | $2\frac{1}{2}$ | 3 | $3\frac{1}{2}$ |
| Approximate quantity in gallons raised per hour on a track of 10 ft. radius | 384 | 555 | 751 | 983 | 3836 | 5524 |
| Maximum vertical height in feet to which one horse or bullock can raise the above quantities | 320 | 210 | 160 | 120 | 90 | 40 |

**Water**, as a motive power, can be utilized in a variety of ways for raising water from a lower to a higher level, the mode of its application depending on its amount and the available fall. Prime movers operated by water are machines which utilize the power latent in a fall of water by converting it into motion. This motion may be *rotary*, as in water wheels and

[1] These figures appear not to include interest and sinking-fund on the cost of the different plants, and if this is the case the figures given for mechanical pumping ought to be increased.

turbines, *reciprocating*, as in water engines, or by *impact*, as in the hydraulic ram.

Amongst the rotary class are the various types of **water wheels** and




Plan of horse-gear and stay rods for four animals

Fig. 270.—J. Tylor & Sons' Horse-gear Three-throw Pump

turbines, revolving either vertically or horizontally. Turbines are usually of the latter class, whilst water wheels are known as "overshot", "undershot", and "breast" wheels, according to the point or height at which the water is delivered on to them. The action of these wheels depends on the weight and pressure of the water entering the buckets, or impinging against the floats which are fixed on the outer rims or peripheries of the wheels. Except under the most favourable conditions they seldom develop more than from 35 to 70 per cent of effective work. The maximum results are obtained when the wheels are moving at about half the velocity of the current driving them, and when the water enters without shock and leaves without velocity. With falls of

less than 6 ft., Poncelet's undershot wheel gives good results, the water being led down an incline of 1 in 10 to impinge on the curved blades near the bottom of the wheel, nearly the whole of the energy being absorbed, and the water leaving with very little velocity.

**Turbines** usually revolve horizontally, on a vertical axis, at a considerable speed, with an effective power of from 60 to 80 per cent, loss being caused by the water entering with a shock and leaving with a velocity. Revolution is caused by the reaction of water flowing from curved surfaces in a plane usually at right angles to that of the entering water, which is conducted by a set of fixed guide curves into the revolving wheel and impinges against the buckets or curved partitions in the latter. They are termed "outward", "inward", or "parallel" turbines, according to the manner in which the water enters them.

Turbines are not affected by the back water, and will run as well when submerged as when clear of the tail water. They occupy little space, and are particularly suitable in situations where the current is small and the fall considerable.

**Steam** as a motive power for driving pumping machinery has hitherto been one of the most important agents employed. The steam engines may either be "high-pressure" or "condensing". The former exhaust their steam direct into the air, and, although they are cheapest in first cost and suitable for moderate installations, they necessitate heavier charges for working expenses. Condensing engines may either be simple or compound, according to the number of expansions. Their initial cost is higher than those of the high-pressure type, but the working expenses are less owing to the saving in fuel, and there is much less strain on the pipes and connections.

It is considered that an ordinary direct-acting steam pump will, for a given service, require a greater coal consumption than an electrically driven pump of the same capacity, in spite of the intermediate efficiency losses in engine, generator, and motor.

A *Horse-power* (H.P.) is equal to the raising of 33,000 lb. through 1 ft. in 1 minute, or to equivalent motion against resistance.

*Nominal Horse-power* (N.H.P.) sometimes denotes only the size of the engine, or the power given out by an engine worked under a steam pressure of about 30 lb. per square inch.

*Indicated Horse-power* (I.H.P.) is the power exerted by the steam in the cylinder.

*Brake Horse-power* (B.H.P.) is the net useful horse-power, *i.e.* the power transmitted from the driving pulley on the crank or first-motion shaft. This is the only practical guide to the users of oil or gas engines.

*Mechanical Efficiency.*—The difference between the indicated horse-power and the brake horse-power is the power absorbed in engine friction, and the ratio of useful (B.H.P.) to total (I.H.P.) work is called the mechanical efficiency.

**Electricity.**—Not the least valuable feature of the electric motor is that it consumes current almost exactly in proportion to the load, so that on the removal of the load the consumption of current ceases, except that required

to overcome friction of the bearings. Where an electric-lighting installation is in operation, current for driving the pumps for the water supply may conveniently be obtained from the same generating plant, or of course it can be obtained in many districts from the mains of an electric-supply company. The pump shown in Plate XVI is worked by an electric motor.

**Oil Engines** for driving pumps are convenient in working and economical in cost. They are particularly suitable where no gas is available, and can be started almost at once, and when stopped the consumption of fuel immediately ceases. Any of the ordinary cheap mineral oils, costing from 5*d.* to 6*d.* per gallon, may be used; but the efficiency of the engine depends to some extent upon the quality of the oil. Whilst the smaller engines consume a little more, the larger sizes can be driven with a consumption of about 1 pint per brake horse-power per hour. Tylor's petrol-driven pump is shown in fig. 271.

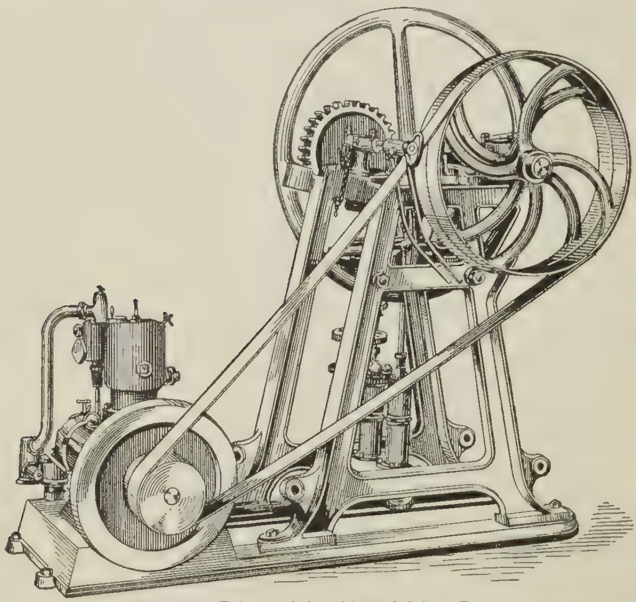


Fig. 271.—J. Tylor & Sons' Petrol-driven Pump

**Gas Engines** have the advantage over ordinary steam engines in being available for immediate use when required, and there is no loss when not at work. They are comparatively light, easily fixed in position, and when once started require very little attention. If the reservoirs or cisterns for storing the pumped water can be arranged of the proper capacity, the gas engines can be run intermittently, so that they can be fully employed during the day, or when the pressure in the gas mains is not required for lighting purposes. While a public gas supply is the most convenient, it is in many cases more economical to install a suction gas plant, by which gas, not pure enough for lighting, but suitable for driving an engine, is obtained as required from cannel coal at a very small cost.

From 17 to 25 cu. ft. of gas per hour is the average consumption per indicated horse-power, according to the size and design of the engine, the larger sizes requiring the smaller amount. For the same power a greater quantity of the gas obtained from a producer plant is required.

**Hot-air Engines**, where only a small power is required, are the simplest motors in the market. Being without valves or small working parts, and only requiring stoking like an ordinary greenhouse stove, they can easily

be attended to by any unskilled labourer. The flue pipe may be connected to an ordinary house chimney if convenient, or an independent flue of cast- or wrought-iron stove pipe may be used.

For powers up to 1 H.P. they are considered preferable to any other form of engine for raising water, on account of their efficiency, safety, convenience of working, and economy. The cost of fuel, which may be small coke, hard wood, or oil, amounts to about 1*d.* only for each 1000 gal. raised 80 ft. high. They can be obtained in sizes of $\frac{1}{4}$, $\frac{1}{2}$, and 1 horse-power, combined with the pumps for suctions not exceeding 25 ft., and in sizes of $\frac{1}{2}$ and 1 horse-power for wells from 28 ft. to 40 ft. deep. The $\frac{1}{2}$ horse-power engine, which is most generally used, will raise 600 gal. an hour 70 ft. high, or 220 gal. an hour 180 ft. high. Only a moderate degree of heat is required to operate the engine.

**Windmills or Wind Engines.**—The force of the wind as a motive power has long been in use for driving corn mills and for drainage purposes. The old type has four arms or sails fixed on an axle placed

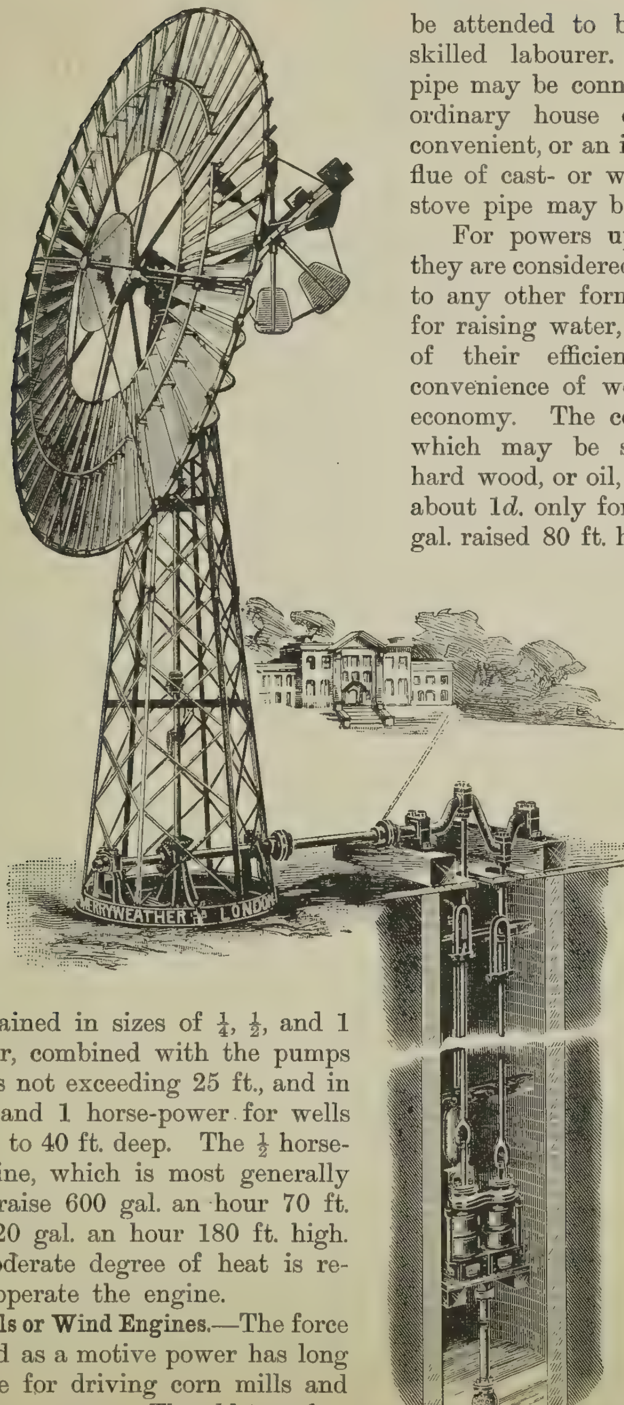



Fig. 272.—Merryweather's Wind Engine and Pump

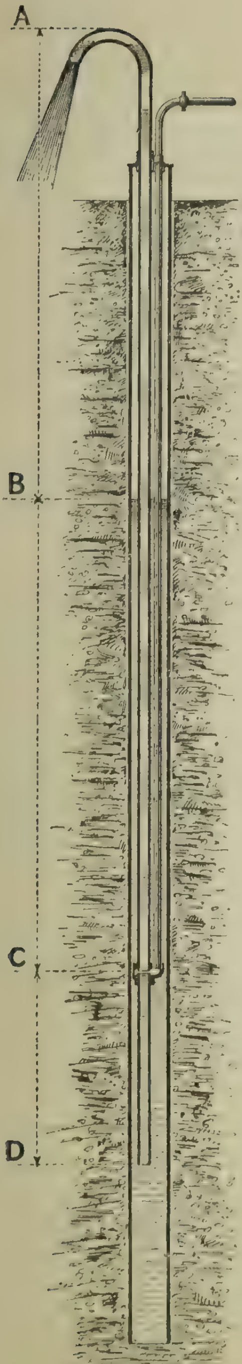
Fig. 273.—Merryweather's Annular Windmill

at an angle of from 8° to 15° to the horizon, and having a toothed or crown wheel, which, by gearing with a bevel wheel on the vertical shaft, imparts motion to the mill-stones, &c. Means are provided for regulating the sails and for turning the whole structure round, so that the sails face the wind from whatever direction it may be blowing. As supplied for pumping purposes they are now much simpler in construction, having more blades or sails of a smaller size, arranged round a circular wheel. Whilst they are very economical, they cannot be depended on for regular work, as there may be no wind or not enough to produce the necessary motion, or it may be too strong. Where, however, the wind is fairly constant, they are useful.

Merryweather's wind engine, with self-regulating gear (fig. 272), consists of a hexagonal steel tower, 24 ft. high, carrying a powerful wind engine, which drives, by means of a vertical shaft and bevel gearing, a horizontal shaft connected to a set of double-barrel deep-well pumps. A steering wheel keeps the head to the wind, and the vanes are arranged to open automatically against an excessive wind pressure to avoid damage to the works. By means of a lever the vanes can be opened or shut by hand if required.

Approximately these windmills will pump water from a well 30 ft. deep to a height of 100 ft., as stated below:

| | | |
|---|---|---|
| 14 ft. diameter | 6000 gals. | per day with a good breeze. |
| 16 ,, | 9000 ,, | |
| 18 ,, | 15,000 ,, | |
| 20 ,, | 20,000 ,, | |



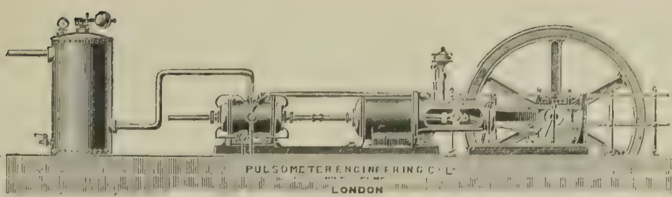




Fig. 274.—The "Mammoth" Air-lift Pump

A small windmill in an exposed position will do more work than one of a larger size less favourably situated, and hence different sizes of pumps will be required for various quantities, depths, and heights.

Fig. 273 shows one of Merryweather's annular windmills with rotary tail, self-adjusting and arranged for pumping from a well 50 or 100, or even 200 ft. deep. The tower or standard is utilized as a water tank, and when this stands on high ground it may supply all the adjacent buildings by gravitation. Owing to the uncertain nature of the wind it is necessary to provide storage accommodation for at least three days' consumption. To guard against a prolonged calm it is frequently found necessary to have a small gas, oil, or other engine in reserve, and this can be put in gear with the pump by means of a clutch provided for the purpose.

**Airlift for Water.**—For this method of raising water (fig. 274) the only plant required in addition to the delivery pipe or rising main is a motor of some sort to compress the air, a receiver to store it in, and a pipe of small diameter to convey it down the well either within the rising main or alongside it. The lower end of this air pipe should terminate at some distance from the bottom of the rising main, and it should be so constructed as to distribute the air in as fine a state of subdivision as possible, the success of the operation depending on the equal diffusion of the air in the column of water. As the air is forced into the rising main and mixes with the water, the latter becomes lighter and consequently rises, being forced up by the atmospheric pressure on the water in the well until it overflows at the top, almost in a continuous current.

The motive power which works the compressor may be a fixed steam engine driving direct, a portable steam engine, or a gas or oil engine,

driving by means of belts or gearing. The receiver for storing the compressed air is a wrought-iron or steel cylinder, strong enough to withstand an internal pressure equal to the maximum head of water which is likely to be brought to bear on it.

There are no moving parts or valves to get out of order; hence the system is suitable for dealing with sandy water, or with water from ironstone beds when the aeration precipitates the iron. Another point is that, for successful working, the nozzle must be immersed to a depth not less than the height to which the water has to be lifted, so that it is impossible to lower the water level more than one-half the total depth of the well or boring.

Fig. 274 shows the "Mammoth" Air-Lift Pump as supplied by the Pulsometer Engineering Company, Ltd. A special footpiece is used at C. For

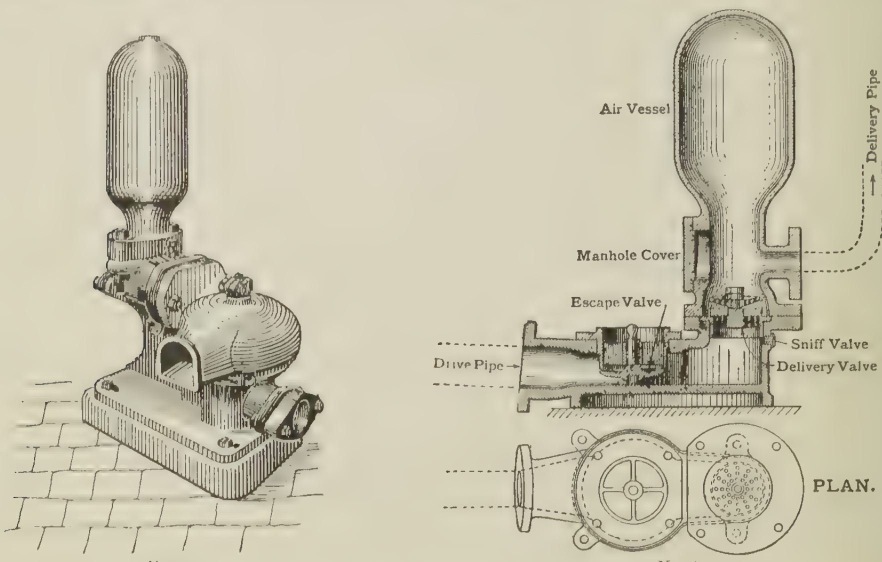


Fig. 275.—Two Varieties of Hydraulic Ram

satisfactory working the distance BC should be half as much again as AB, B being the level of water whilst working.

Where a number of borings are driven at a considerable distance apart, for the purpose of supplying a large quantity of water, the compressor installation can be erected at some central position, providing all the moving machinery required, and the air pipes can be laid underground to each of the borings.

**Hydraulic Rams.**—A hydraulic ram (fig. 275) is an apparatus for automatically raising water from a lower to a higher level. It is a durable and useful machine, costing nothing for power, requiring little attention, and moderate in first cost.

The action is very simple, the motive power being due to the momentum of the water in the drive pipe which feeds the ram. The drive pipe is laid with a slope of about 1 in 10 towards the ram; the water, rushing

through the apparatus and escape valve (which opens inwards), suddenly closes the latter, and the result of the check is that the water seeks another outlet, which it finds in the air vessel and delivery pipe. The air in the vessel is compressed and on expanding forces a portion of the water up the delivery pipe, and by closing the delivery valve prevents its return. In the meantime the escape valve opens, the pressure being relieved by the recoil of the water, and the operation is again repeated, and the water raised by a series of impulses. The sudden rise of pressure in the ram is equal to the weight of water in the drive pipe multiplied by its velocity.

An efficient ram will force one-third of the drive water to $2\frac{1}{2}$ times the height of fall, one-sixth to 5 times the fall, and one-tenth to 8 times the fall. Rams are also made to raise pure spring or well water by the action of impure or other water, without any risk of the waters mixing, which is occasionally a great advantage.

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# CHAPTER V

## WATER MAINS AND FITTINGS

The pipes which convey the water from the Water Company's works or reservoirs, for distribution throughout a town or district, are usually termed *mains*, and the branches or "communication" pipes, which conduct the water from them to each separate house or block of buildings, are known as *supply* or *service pipes*.

The materials used for mains are chiefly cast iron, wrought iron, and steel, and, under certain conditions, lead.

**Cast-iron pipes** have hitherto been most generally used. They are frequently specified to stand a pressure of 400 ft. head of water, which is equivalent to 173 lb. per square inch, and to be tapped with a hammer whilst under pressure. All cast-iron pipes should be from the second melting of No. 3 quality pig iron, cast vertically, or at an angle of 45°, in dry sand with sockets down, uniform in section and thickness of metal throughout, and free from flaws, sand, or blow holes, &c.

The object of casting the pipes with the sockets downwards is that additional strength may be given to them by being cast under pressure, so that they are better able to resist the blows when the caulking material is being driven home.

In casting, the dross in the iron rises to the top, and the upper end of the pipe is therefore likely to be weak and porous. For this reason water mains are often cast one foot longer than the finished size, the extra length being afterwards removed in a lathe.

On account of the brittleness of cast-iron pipes they are liable to fracture under sudden strains, caused by increased pressure and by hydraulic blows or "hammering" in the pipes, and by sinking or other movement of the line of pipes.

They can be manufactured in sizes from $1\frac{1}{2}$ in. in diameter upwards.

| | |
|---|---|
| Up to 3 in. diameter they are made in lengths of 6 ft. | Exclusive of Sockets. |
| From 3 in. to 12 in. diameter they are made in lengths of 9 ft. | |
| Above 12 in. diameter they are made in lengths of 12 or 15 ft. | |

When intended to stand a pressure of 600 ft. head of water (or 260 lb per square inch), they should be of the sizes and weights given in the following table:—[1]

| Internal Diameter. | Thickness of Metal. | Normal Weight of Pipe inclusive of Socket. | | Length of Pipe exclusive of Socket. | Inside depth of Socket. | Inside diameter of Socket. | Lead Joint for Socket Pipes.[2] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Socket Joint. | Turned and Bored Joint. | | | | Thickness. | Depth. | Weight. |
| In. | In. | Cwt. qr. lb. | Cwt. qr. lb. | Feet. | In. | In. | In. | In. | Lb. |
| 2 | ·380 | 2 4 | 2 6 | 6 | 3 | 3·260 | $\frac{1}{4}$ | $1\frac{1}{2}$ | 1·4 |
| 3 | ·400 | 1 0 24 | 1 0 26 | 9 | $3\frac{1}{2}$ | 4·300 | $\frac{1}{4}$ | $1\frac{3}{4}$ | 2·3 |
| 4 | ·420 | 1 2 16 | 1 2 20 | 9 | 4 | 5·465 | $\frac{5}{16}$ | 2 | 4·0 |
| 5 | ·451 | 2 0 22 | 2 0 27 | 9 | 4 | 6·527 | $\frac{5}{16}$ | 2 | 5·0 |
| 6 | ·481 | 2 3 0 | 2 3 6 | 9 | $4\frac{1}{4}$ | 7·587 | $\frac{5}{16}$ | $2\frac{1}{4}$ | 6·5 |
| 7 | ·496 | 3 1 8 | 3 1 15 | 9 | $4\frac{1}{4}$ | 8·617 | $\frac{5}{16}$ | $2\frac{1}{4}$ | 7·7 |
| 8 | ·510 | 3 3 14 | 3 3 22 | 9 | $4\frac{1}{4}$ | 9·645 | $\frac{5}{16}$ | $2\frac{1}{4}$ | 8·2 |
| 9 | ·532 | 4 2 0 | 4 2 9 | 9 | $4\frac{1}{2}$ | 10·689 | $\frac{5}{16}$ | $2\frac{1}{2}$ | 10·4 |
| 12 | ·627 | 7 0 0 | 7 0 12 | 9 | $4\frac{1}{2}$ | 14·004 | $\frac{3}{8}$ | $2\frac{3}{4}$ | 18·0 |

The flanges and bolts for cast-iron pipes should be, according to the same authority, as under:—

| Diameter of Pipe. | Diameter of Flange. | Thickness of Flange. | Number of Bolts. | Diameter of Bolts. | Diameter of Circle of Bolts. |
|---|---|---|---|---|---|
| Inches. | Inches. | Inches. | | Inches. | Inches. |
| 2 | $5\frac{1}{4}$ | $\frac{1}{2}$ | 3 | $\frac{7}{16}$ | $3\frac{3}{4}$ |
| 3 | $6\frac{1}{2}$ | $\frac{5}{8}$ | 4 | $\frac{1}{2}$ | 5 |
| 4 | 8 | $\frac{5}{8}$ | 4 | $\frac{9}{16}$ | $6\frac{1}{4}$ |
| 5 | $9\frac{1}{4}$ | $\frac{3}{4}$ | 4 | $\frac{9}{16}$ | $7\frac{1}{2}$ |
| 6 | $10\frac{1}{2}$ | $\frac{3}{4}$ | 6 | $\frac{9}{16}$ | $8\frac{3}{4}$ |
| 7 | 12 | $\frac{3}{4}$ | 6 | $\frac{5}{8}$ | 10 |
| 8 | $13\frac{1}{4}$ | $\frac{7}{8}$ | 6 | $\frac{5}{8}$ | $11\frac{1}{4}$ |
| 9 | $14\frac{1}{2}$ | $\frac{7}{8}$ | 6 | $\frac{5}{8}$ | $12\frac{1}{2}$ |
| 12 | $18\frac{1}{4}$ | 1 | 6 | $\frac{3}{4}$ | 16 |

Branches, junctions, and bends, &c., should correspond in thickness, &c., to the figures given in the above tables.

[1] From *Water Supply to Barracks and Cantonments*, by Major (now Col.) G. K. Scott-Moncrieff, R.E.

[2] If the turned and bored joints are also run with lead, the quantity of lead required will be approximately three-fourths of that shown for the socket pipes of corresponding size.

**Joints in Cast-iron Pipes.**—Cast-iron pipes are made either with spigot-and-socket joints, or with flanges, and the spigots and sockets may be plain or turned and bored. The method of forming the joints with the **spigot-and-socket pipes** (fig. 276) is first to insert the spigot of one pipe into the socket of the other, and then to force some strands of gasket (white or untarred yarn) into the joint, so as to prevent any of the molten lead, which is afterwards run in, from finding its way into the interior of the pipe and causing an obstruction. The bead which is usually cast on the spigot end of the pipe partly prevents this, and also serves with the gasket to ensure the pipes being kept in line and concentric. The gasket should be driven tightly home, and a piece of well wetted or greased rope is placed round the mouth of the socket to prevent the clay luting from

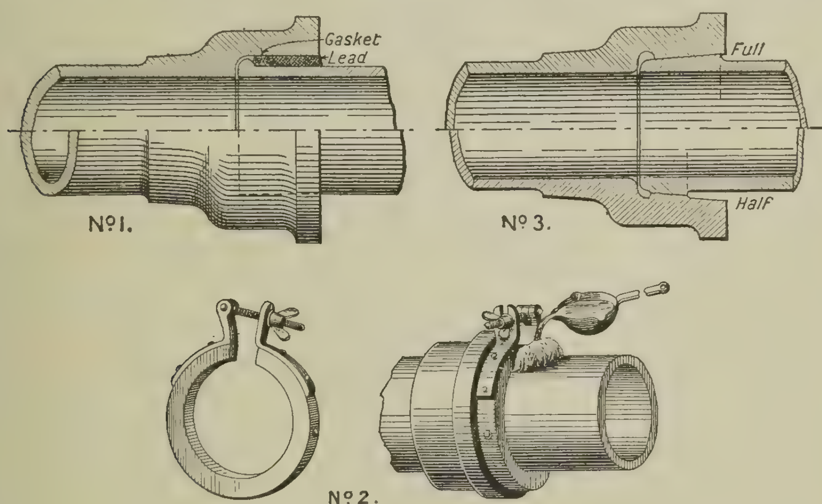



Fig. 276.—Joints in Spigot-and-socket Pipes
No. 1, Caulked joint; No. 2, Turned and bored joint; No. 3, Clip or ring.

entering the joint. After the clay has been moulded round it, the rope is gently withdrawn, leaving the clay band all round the joint, except at the top, where a small opening or "gate" is left, into which the molten lead is poured, sufficient being run in to fill the joint. The clay band is then cleared away, and the lead thoroughly compressed by means of a caulking tool until the joint is uniform all round. In forming the joints of large pipes a saving in time and lead may be effected by using a clip or ring, as shown in fig. 276, No. 2. As the gasket is liable to rot in time, and to contaminate the water, lead wire and lead "wool" are sometimes used instead of yarn for caulking water pipes. Iron or rust-joint cement is also occasionally used as a jointing material.

In a trench it is somewhat difficult to caulk the joints properly on the under side; so with the lighter pipes it is the usual custom to put two or three lengths together on the bank, to reduce the number of joints to be formed in the trench. Great care must be taken in slinging and lowering these double or treble lengths, so as not to strain the joints, and the bottom

of the trench itself should be formed to an even gradient to allow the full length of the pipe to rest on a good solid bottom. It will be necessary to excavate a little deeper where the joint has to be run in the trench, and this space should be carefully filled in and rammed after the line, or each separate section of the line, has been completed and tested.

Two spigot ends may be connected by means of a *double socket*, which is a short length of pipe having a socket at each end. The cut ends of two pipes may be connected by means of a *collar*, which may be a special casting strengthened at the ends, or merely a plain piece of pipe. In either case it must be of sufficient diameter and length to enable a proper leaded joint to be formed when it is slipped over the abutting ends of the pipes to be joined. Special cast clips and collars are obtainable for the repair of burst pipes or sockets.

**Turned and Bored Joints** are sometimes used when it is desired to carry out the work quickly, or where the pipes are to be laid in water-logged ground. A portion of the spigot and socket is carefully turned and bored to a slightly conical shape (fig. 276, No. 3), so that when connected up they form an accurate metallic contact joint. The turned and bored portions may either be "full" or "half". When the joint is only half turned and bored, there is a space left which can be run with molten lead and caulked, if there is any sign of leakage when the hydraulic test is applied.

The extra cost of the turned and bored pipes is compensated for by the rapidity with which they can be laid, but when the joints require to be leaded the cost is increased. When properly made and put together, they should not require to have the joints run, unless the head of water exceeds 300 ft. The question of expansion and contraction, however, requires consideration, this depending on the temperature at the time of laying. Expansion may cause split sockets and contraction leaky joints. Some engineers introduce a plain socket at every tenth joint, to take up any expansion or contraction.

In putting the pipes together, it is necessary to see that the turned and bored portions are thoroughly cleaned and well coated with red-lead cement applied with a brush, or that a solution of sal-ammoniac is applied, so that the turned surfaces may rust together. A mixture of tallow and resin is sometimes used, or even liquid Portland cement. The pipe to be laid, after the above treatment, is gently driven home by tapping with a maul, a block of wood being placed against the socket at the other end of the pipe.

One disadvantage of the turned and bored pipes is that they do not admit of any slight deviation of the line, such as can be effected with the spigot-and-socket pipes. Pipes with turned spigots can be inserted into an ordinary socket, but the bead on the ordinary spigot must be partially filed away to enable it to enter a bored socket.

**Flanged Cast-iron Pipes** (fig. 277) are put together with bolts and nuts, the number of which will depend on the diameter of the pipe, as stated in the table on p. 264. These joints can be more easily put together or taken apart than socket joints, and for this reason also they are very convenient for connecting sluice valves, meters, hydrants, or other similar fittings to the pipes.

In some cases, as, for example, when the pipes are fixed vertically, the whole of the meeting faces (A) of the flanges are brought to a true plane, so as to secure a metallic contact, which is supplemented by smearing them with red-lead cement, in which some strands of hemp are embedded before screwing them together.

To save machining such a large surface, the faces of the flanges near the periphery are sometimes slightly recessed, leaving the inner portions only (B) to be faced in the lathe. The faces may be rendered more water-tight by having rings of packing, such as india-rubber and canvas or lead, bolted between them, a groove being occasionally formed for the ring.

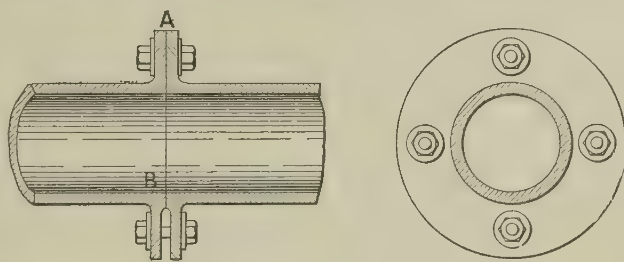


Fig. 277.—Flanged Joint

Whilst these flanged pipes are convenient for some purposes, they do not admit of much expansion or contraction, and are not so convenient to pack for transport, which is a great consideration when required for shipment abroad.

Special **Expansion Joints** (A, fig. 278) are supplied when required, also **Ball-and-Socket Joints** (B), which admit of a slight deviation from a straight line in cases of subsidence or horizontal deflection.

The usual method of **protecting cast-iron pipes** from oxidation is to

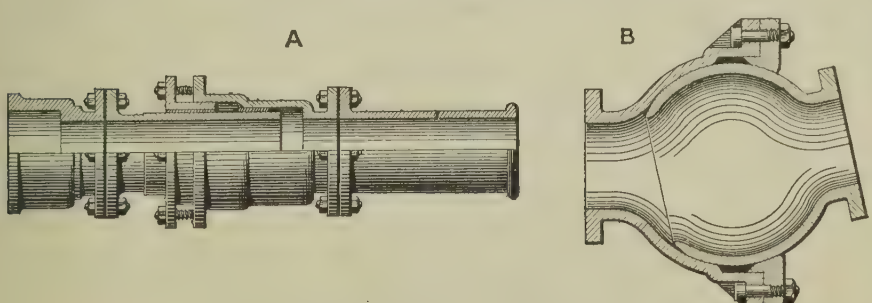


Fig. 278.—A, Expansion Joint; B, Ball-and-socket Joint

coat them with Dr. Angus Smith's solution, or to apply the Bower-Barff process. These have been described in Section I, p. 19.

**Wrought iron** and **mild steel** are now frequently used for water mains instead of cast-iron, which, on account of its brittleness, low tensile stress, and liability to flaws in casting, is found to be not altogether trustworthy.

Although wrought-iron and mild-steel pipes cost more per ton than cast-iron, the price per foot run is less, owing to the lightness of the former in comparison, and this reduced weight for the same length of main is of considerable importance where carriage is difficult or expensive. Being

tougher and more ductile, they can be made thinner for equal strength, and are less liable to damage during transit.

The objection to their greater liability to oxidation than cast-iron has been partially met by the improved methods of preservation now available. Where the ordinary method of galvanizing has been insufficient to protect them from the acids in certain earths (inducing electrolysis and consequent destruction of the zinc coating and corrosion of the pipes), it has been found that a coating of natural asphaltum on the top of the galvanizing is as good a preservative as that of Dr. Angus Smith's process applied to cast-iron pipes. Under ordinary conditions the coating of natural asphaltum is not affected by water, earth, or the atmosphere, and this method of coating pipes is usually adopted in the United States.

The patent composition used by the Steel Pipe Company (Kilmarnock) consists of refined natural asphaltum and certain other ingredients, which when melted in a bath and heated up to 250° F. produce a hard, smooth, and glassy surface on the pipes immersed. The smooth coating is said to reduce the frictional resistance to the flow of water, and to prevent the accumulation of deposit, which is so common with cast-iron pipes.

The same company states that: "Making due allowance for loss of strength in the welded and riveted seams of steel pipes, and taking the usual factors of safety into consideration, the relative strengths for pipes of equal diameter and thickness are:—

| Cast-iron. | Wrought-iron. | Mild steel. |
|---|---|---|
| 1·00 | 3·15 | 5·60 |

"In other words, if a cast-iron pipe is designed for a working pressure of 100 lb., the same pipe in wrought-iron may be safely worked to 315 lb., or in steel to 560 lb. pressure.

"As the extra strength of steel over cast iron is seldom required except in special cases, it is usual to make them of equal strength, and so reduce the thickness and consequent weight of the steel pipes. The relative thicknesses for pipes of equal diameter and strength are:—

| Cast-iron. | Wrought-iron. | Mild steel. |
|---|---|---|
| 1·00 | 0·3174 | 0·1786 |

"In other words, if a cast-iron pipe is required 1 in. thick, the same strength would be obtained from a wrought-iron pipe $\frac{5}{16}$ in., and from a steel pipe $\frac{3}{16}$ in. thick."

Steel pipes can be obtained in lengths of from 12 to 16 or 20 ft.; consequently fewer joints are required than with cast-iron pipes. Welded steel pipes are recommended in preference to riveted, and are mostly used for the smaller sizes and where the pressure may be high. Solid pipes, rolled from steel ingots, are now manufactured for small diameters.

Steel pipes are fitted together with ordinary spigot-and-socket joints, flanged joints, or with a double socket.

**The Riley Patent Socket Joint** (fig. 279) is formed with spun yarn and lead similar to the ordinary spigot-and-socket joint, a stamped steel socket being riveted on to one end of the pipe. With welded pipes no special

spigot is necessary, but with riveted pipes a special welded steel spigot is riveted on as shown in the illustration.

**Flanged Joints** for riveted steel pipes are formed by riveting stamped-steel flanges on the ends of each pipe and bolting them together (fig. 280). The flanges are truly faced in dies, the bolt holes are drilled, and rubber insertion, sheet lead, or other suitable jointing used.

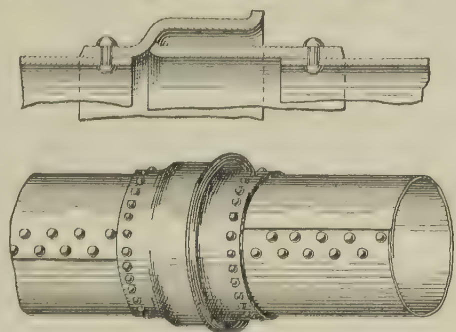


Fig. 279.—The Riley Socket Joint for Riveted Steel Pipes

**The Double Steel Socket or Sleeve Joint** (fig. 281) is formed by slipping a loose sleeve over the ends of the pipes to be joined, and then by means of spun yarn and lead forming a double-socket joint. The sleeve is made of steel bar rolled to the desired section, curved into a ring, and welded. This joint is known as the "Kimberley" sleeve joint, from having been used at the Kimberley Waterworks.

**Conduits and Pipes.**—When water has to be brought from an impounding reservoir at a considerable distance, the mode of its conveyance to

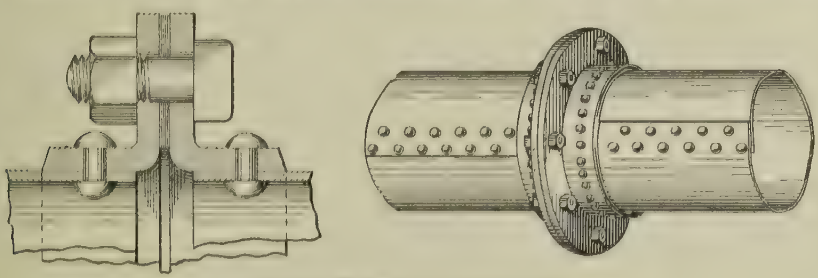


Fig. 280.—Flanged Joint for Steel Pipes

the storage reservoir depends on the nature of the country through which it passes. It may be practicable to use open or closed conduits or channels laid with sufficient fall to give a current, although part may be in a cutting, part in a tunnel, and a portion on an embankment or carried across a valley on an aqueduct. When the water is brought in open channels from very high ground, where the natural fall would cause a too rapid flow, one or more **Balancing Reservoirs** are formed so as to check the rush, and bring it to a state of rest. Sediment will be deposited in these reservoirs, and the water allowed to pass on with diminished velocity to the next, or to the service reservoir itself.

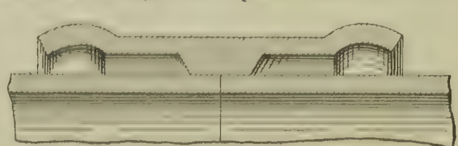


Fig. 281.—Double Steel Socket or Sleeve Joint

It is usually necessary, however, to utilize pipes for conveying the water to the storage reservoir. These pipes should be laid at a sufficient

depth underground to protect them from frost and sun, and as they would generally follow the natural configuration of the ground, they would be more or less under pressure. It is therefore necessary that the whole line of pipes should be thoroughly under control, and to ensure this result

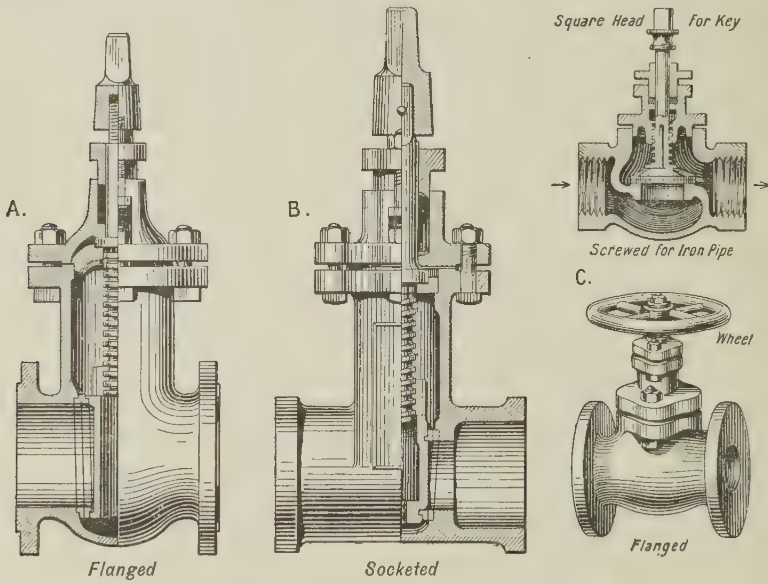



Fig. 282.—A and B, Sluice Valves; C, Stop Valves

valves and other fittings are required. This is also necessary in the case of the distributing mains from the service reservoirs.

**Sluice valves or Stop cocks** (fig. 282) are required to shut off or turn on the water in the mains, or to isolate certain sections for repairs or for fresh connections to be made, or for meters to be removed or examined without having to cut off the whole system. They are usually termed sluice valves when fitted to pipes over 2 in. in diameter, and stop valves or stop cocks when used with pipes of less than 2 in. diameter. Another distinction is that a sluice valve is opened at right angles to the direction of the pipe, exposing a straight way or gate through it, whereas a stop valve has an orifice somewhat as shown in the section at C.

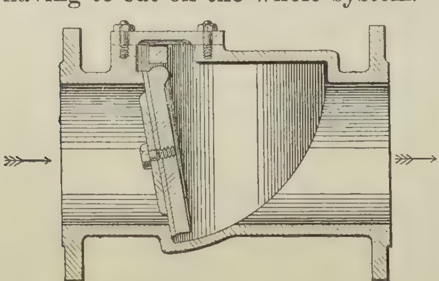


Fig. 283.—Reflux Valve

**Reflux, Retaining, or Back-pressure valves** (fig. 283) prevent the water from flowing back in mains when the pressure is taken off. They act automatically, closing when the water begins to flow backwards, but opening again when the normal flow is resumed.

**Throttle valves** (A, fig. 284) automatically prevent the water running to

waste in case of a burst, coming into action when the rush of water exceeds a certain velocity, and gradually bringing it to rest. They have to be reset by hand. B shows a hand throttle valve.

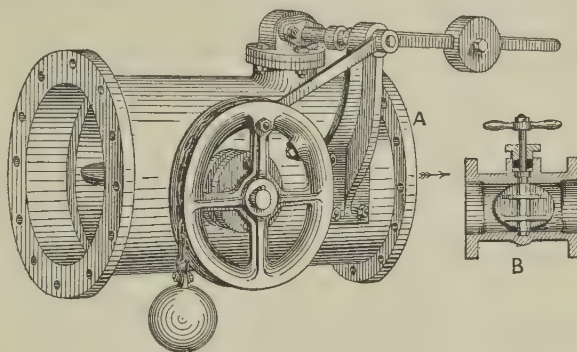



Fig. 284.—Throttle Valves. A, Self-acting; B, Hand.

**Scour valves or Wash-out valves** are fixed at dips or in the lower portions of mains, so that these can be emptied when required. They may be ordinary sluice valves placed at the ends or on short branches from the mains.

**Air valves** (fig. 285) are fixed at the highest portions of undulating mains to allow the air which collects there to escape. They are specially necessary when the mains are

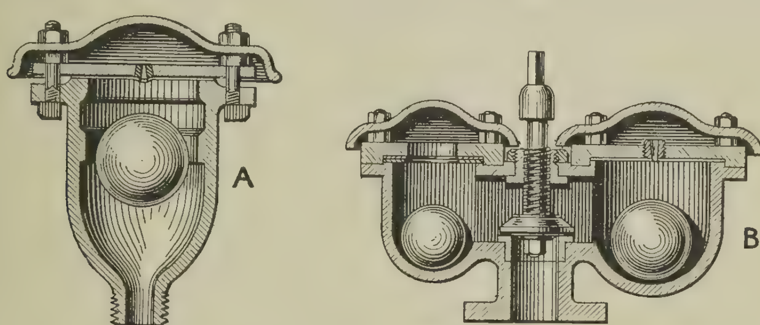



Fig. 285.—Air Valves. A, Single; B, Double

being filled, as the air in the pipes rises to the summits and obstructs or retards the flow of water. The floating ball rises and prevents the escape of water after the air has been expelled. They may be single or double as shown. B is fitted with a screw-down valve which, when shut as shown in the illustration, enables the air valves to be repaired without stopping the flow of water in the main.

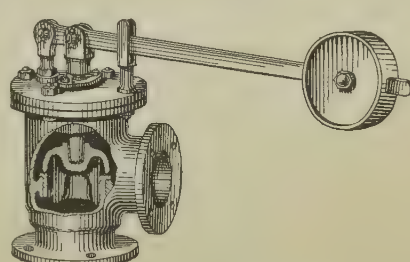


Fig. 286.—Escape or Relief Valve

**Ball valves** are for regulating the supply to consumers' and other cisterns, by means of a floating ball at the end of a lever, which opens or shuts the inlet as the ball falls or rises in the cistern. (See Plate XVII and fig. 288.)

**Escape or Relief valves** (fig. 286) fixed on mains allow the escape of water when a certain pressure is exceeded and so reduce the concussion. They are usually fitted with springs or weighted levers.

**Pressure-reducing valves** (fig. 287) are intended to keep the pressure in the mains within certain limits, which can be raised or lowered at pleasure by means of springs or weighted levers. The outlet pressure on the discharge side of the valve is thus constant and independent of varying pressures on the inlet.

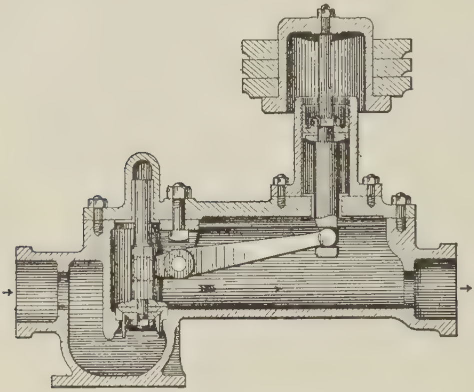


Fig. 287.—Pressure-reducing Valve (Caldwell's)

**Break-pressure Tanks.**—When a service reservoir serves a town or district which varies very much in the levels, it may be found advisable to form additional reservoirs at convenient points at lower levels, to supply the low-lying portions of the district. These break-pressure tanks serve to reduce the pressure in the mains, which it is desirable to keep under (say) 250 ft. of head on the distribution system. They may be built of brickwork or concrete and

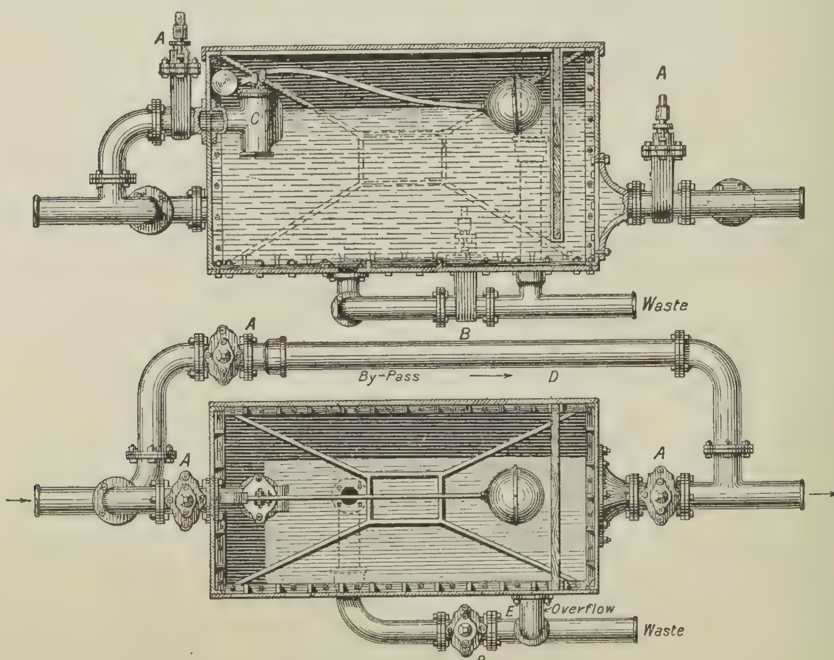



Fig. 288.—Break-pressure Tank of Cast Iron

A, A, A, Sluice valves; B, sluice valve for cleaning out; C, ball valve; D, by-pass; E, overflow.

covered over, or may be of cast iron (fig. 288) and fixed direct on the distribution main, a ball valve C partly closing the inlet when the outlet pipe is full. A by-pass D controlled by a sluice valve A is usually pro-

vided, also an overflow E, and the tank can be emptied and cleaned after closing the two valves A at the ends of the tanks and opening the waste valve B, the supply meanwhile being maintained through the by-pass.

Each outlet from the various reservoirs and tanks should be provided with a **strainer, screen,** or **rose** to keep back fish, and solid or floating substances, from entering the mains, their shape depending on the form and position of the outlets. Fig. 289 shows one form of screen suspended over the reservoir outlet. Like the sluice valve governing the outlet, it can

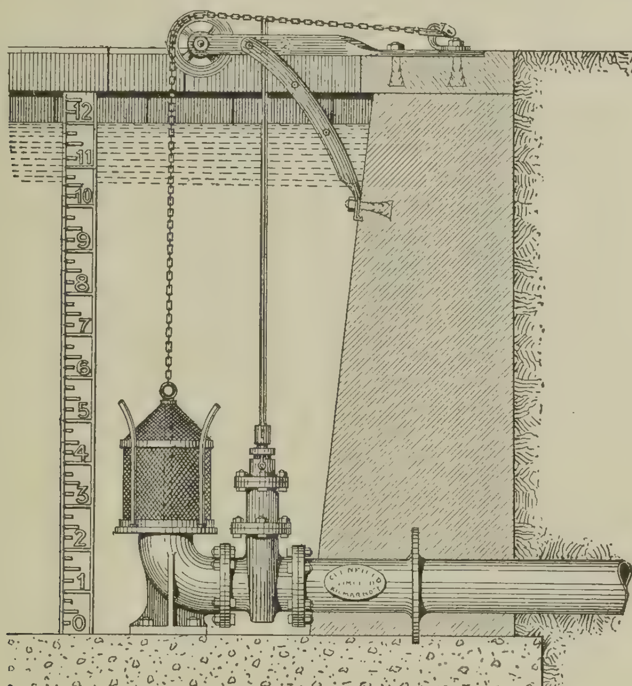



Fig. 289.—Strainer for Reservoir Outlet

be worked from the surface. The gauge plate showing the depth of water is also illustrated.

**Maintenance of Water Supply System.**—To ensure satisfactory results in the working of a water supply system the whole of the fittings should be of good quality, and be kept in good order. All valves and movable parts should occasionally be worked to their full extent, and kept free from rust and dirt, &c. Deposits in the mains may be partly flushed out at the scour valves, and incrustation may be loosened or cut by special scrapers and then washed out. Instead of having to break into the mains, special castings termed *hatch boxes*, having movable covers, are sometimes fixed at intervals to admit the scrapers, which may be attached to rods and worked by hand for pipes up to 6 in. diameter, or driven through the larger sizes by the pressure of water behind them. The operation should be carried out in sections, working in the direction of the flow towards the scour valves placed at the dips, the sluice valve *beyond* being closed.

# CHAPTER VI

## DOMESTIC SERVICE PIPES AND FITTINGS

The pipes in which water is conveyed to or through houses for domestic purposes are generally known as "services", or "service pipes". The pipe connecting the main with the cistern, or with the house itself, where there is no cistern, is known as the "communication" or "supply" pipe, whilst those branches which terminate at points where water is delivered are termed "delivery" pipes. All these pipes are usually of wrought iron or lead, or of either of these materials lined with tin.

As already explained, water mains laid underground are generally of cast iron, and since these can be obtained as small as 2 in. in diameter, or even $1\frac{1}{2}$ in., and are more durable than wrought iron, they are usually adopted for underground work when they can be laid at a sufficient depth to prevent their fracture by heavy wheeled traffic over them. This depth ought never to be less than 30 or 36 in., to avoid risk of the water in the pipes freezing.

**Wrought-iron service pipes** may be plain or "black", galvanized, or coated with other preservative. Some soils act very injuriously on iron pipes, and it is always advisable to make use of some preservative such as asphaltum or galvanizing. Asphaltum is sometimes applied to pipes which have been galvanized, as the acids in the earth frequently decompose the zinc coating and cause a rapid corrosion.

It is usually laid down in specifications that service pipes should be of galvanized wrought-iron tubing, either butt or lap welded, capable of withstanding a pressure of 400 ft. head of water (173 lb. per sq. in.), and fixed with all requisite fittings, such as bends, elbows, tees, ferrules, sockets (equal or reducing), "springs", &c., put together with red-lead cement and properly screwed, and that the weights should not be less than the following:—

| | | | | | | |
|---|---|---|---|---|---|---|
| Internal diameter ... ... | $\frac{3}{8}$ in. | $\frac{1}{2}$ in. | $\frac{3}{4}$ in. | 1 in. | $1\frac{1}{4}$ in. | $1\frac{1}{2}$ in. |
| Weight per 10 ft. lineal ... | 6 lb. | 8 lb. | 13 lb. | 19 lb. | 25 lb. | 34 lb. |

**Sizes.**—Wrought-iron pipes or tubes can be obtained in lengths up to 14 or 15 ft., and with diameters varying from $\frac{1}{8}$ in. up to 4 in.,[1] but short lengths termed "pieces" can also be obtained from 3 in. up to $23\frac{1}{2}$ in.

**Joints.**—Wrought-iron pipes are connected together by screw-collar joints, the end of each length of pipe having an external screw thread, whilst the collar has an internal thread. The sleeve or collar (shown in the lower part of No. 8, fig. 290) may have either the ordinary internal right-handed thread cut throughout its length, or both right- and left-handed threads cut in it, half from each end. In the former case the

[1] Most manufacturers supply wrought-iron tubing of the following diameters: $\frac{1}{8}$ in., $\frac{1}{4}$ in., $\frac{3}{8}$ in., $\frac{1}{2}$ in., $\frac{3}{4}$ in., 1 in., $1\frac{1}{4}$ in., $1\frac{1}{2}$ in., $1\frac{3}{4}$ in., 2 in., $2\frac{1}{4}$ in., $2\frac{1}{2}$ in., $2\frac{3}{4}$ in., 3 in., $3\frac{1}{2}$ in., and 4 in.: and in three strengths known respectively as "gas", "water", and "steam" tubing.

SCREW-CUTTING WITH STOCKS AND DIES

PIPE-CUTTING

SCREWING UP PIPES WITH A CHAIN WRENCH

WROUGHT-IRON PIPE WORK

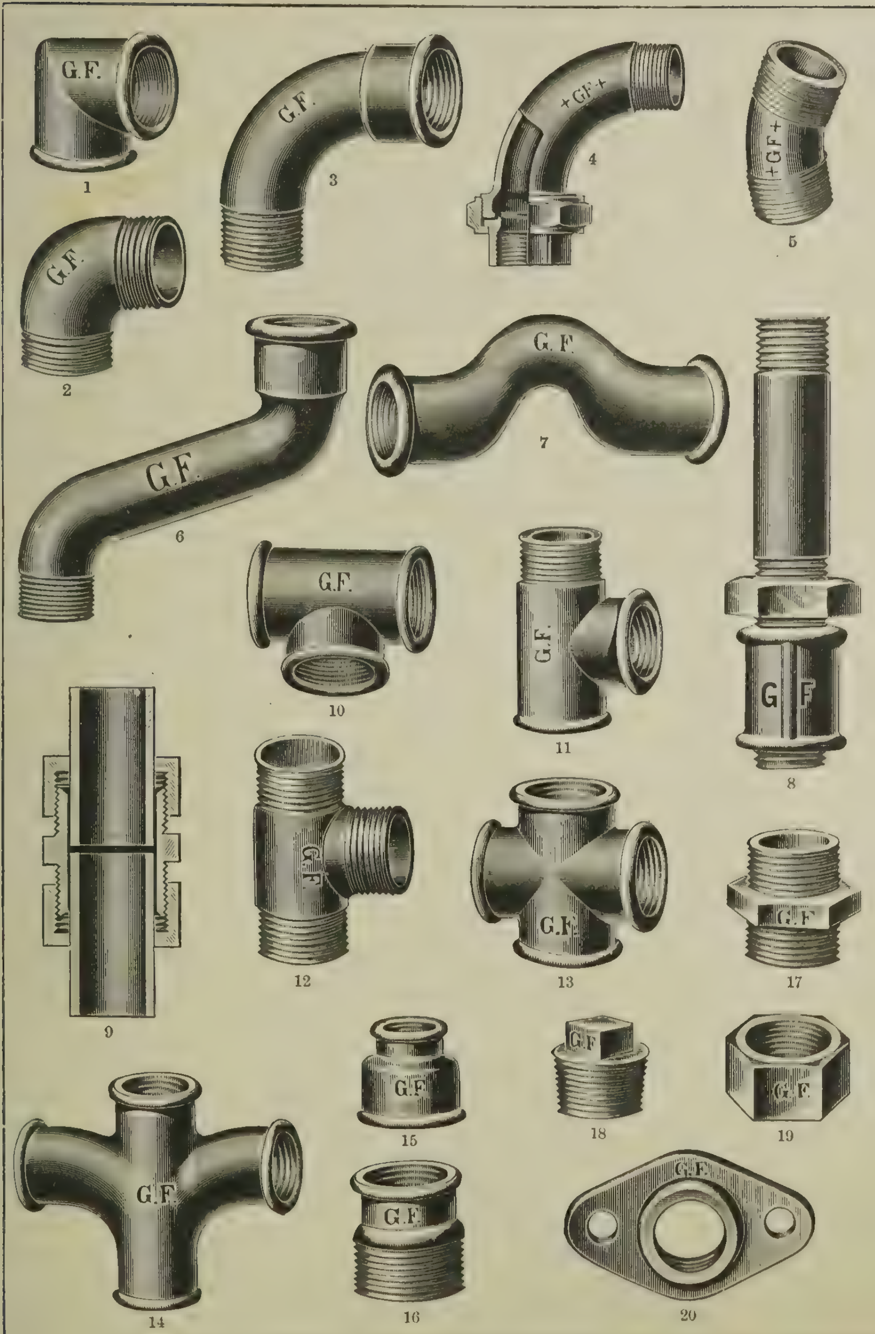



Fig. 290.—Malleable-iron Fittings for Wrought-iron Pipes

screwed ends of the pipes to be joined should be slightly tapered, so that, as the joint is screwed up the threads bind together more and more tightly, whereas the right and left threads draw the ends of the pipes together until they abut tightly against each other. A few strands of spun yarn, smeared with red-lead and carefully wound around the pipe, keep the joint water-tight. The fittings may be wrought or, as in fig. 290, malleable.

When pipes are put together in this way, the operation must be carried out from one end, as in laying cast-iron mains; consequently when a joint requires repair, or a junction has to be inserted, a portion of the work must be disconnected, it may be for a considerable distance. By introducing "connectors" or longscrews (No. 8, fig. 290) at intervals this difficulty is overcome. A thread is cut on one end of the connector of sufficient length to allow the whole of the collar or "socket" to be screwed on to it, and a thread of ordinary length is formed on the other end; when the pipes are in position, the collar is screwed over the joint, and thus holds the pipes together, a back nut or "lock nut" being usually provided as shown. To release the joint the back nut and collar are simply screwed back on to the long thread. The patent union, shown in section in No. 9, fig. 290, is used for uniting pipes without threads, and serves the same purpose as a connector.

**Bends.**—Changes in a right-angled direction should be effected by means of quadrant bends (Nos. 3 and 4, fig. 290) instead of by square or round elbows (Nos. 1 and 2), which greatly retard the flow of water. The larger the radius of the curve can be made, the better the result will be.

When the change of direction is at an obtuse angle, **springs** or easy bends (No. 5) are used. These can be obtained in short lengths for various angles, or the pipe can be heated and carefully bent within certain limits without injuring it or reducing the bore. In the case of galvanized-iron pipes, the heating would destroy the galvanizing if that process had been carried out prior to the bending.

**Branches.**—Tees, or T-pieces (Nos. 10 to 12, fig. 290), and crosses, or X-pieces (Nos. 13 and 14), are used where one or two branches are required on a straight run of pipe, and these may all be either equal or diminishing. Thus, a 1-in. pipe might require to have a $\frac{3}{4}$-in. branch from it, in which case a 1-in. to $\frac{3}{4}$-in. T-piece would be used, or two branches might be required at right angles to the direction of the main pipe, when a cross-piece having a 1-in. main pipe with two $\frac{3}{4}$-in. outlets (on opposite sides) would be introduced.

**Reducing Sockets.**—Pipes may be reduced in diameter either at the tees or crosses, or just beyond them by means of what are termed diminishing or reducing sockets (Nos. 15 and 16, fig. 290). If a bend or elbow is close at hand, it is better to carry the larger pipe up to this point, and then introduce a reducing bend or elbow or a reducing socket just beyond the bend as most convenient.

**Plugs and Caps.**—In view of future extensions, it is sometimes advisable to fix a cross-piece where one branch only is required for the time being, the extra opening being closed by a plug or cap (Nos. 18 and 19, fig. 290), which is screwed to it by means of the square or hexagonal head on its

closed end. This can easily be removed afterwards if it is desired to fix an additional branch, or it may be useful in clearing out the scale or rubbish which may accumulate in the pipe. In the same way a tee could be used instead of an elbow or bend, in certain positions, such as at the foot of a rising pipe, or where it would afford facilities for emptying the pipe of water or deposit.

Whilst a plug can be used to close the opening of a socketed fitting, the end of a pipe can be closed by means of a cap screwed on to it, the cap being similar to the plug but with an internal thread.

**Lead Service Pipes** have been very extensively used, and in many cases they are preferred to wrought iron, on account of the ease with which they can be bent to any required angle, and to the fact that they are less liable to corrosion. The main point for consideration is whether the lead is likely to affect the water injuriously while passing through the pipes. Some authorities contend that the water is in contact with the lead pipe for such a short time, whilst passing through, that there is practically no risk, especially if the precaution is taken, when water is being drawn off for domestic purposes, to let a quantity run to waste, equal to that contained in the pipe, which may have been in contact with the lead for some time.

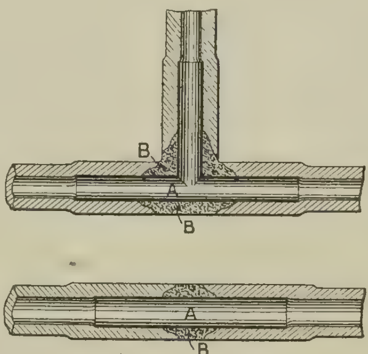


Fig. 291.—"Clear-bore" Joints for Lead Pipes

It is sometimes specified that lead pipes should only be used as supply and discharge pipes for flushing cisterns, overflows, and wastes from safes, &c.

Not only are lead pipes more convenient to be run as services throughout the house, but they are less liable to burst through frost than wrought-iron pipes, as they will yield slightly by bulging before they actually burst. Repeated freezings, however, will have the same effect as the constant opening and shutting of a plug cock has; that is, to cause swelling of the pipe at some weak point, the bulged portion getting thinner and thinner as the expansion goes on, and ultimately giving way. When failure by bursting does take place—if the water cannot conveniently be turned off—a few blows with a hammer are sufficient to close the pipe, and so prevent damage caused by the escaping water, whereas little can be done with a split wrought-iron pipe until the water is shut off.

**Joints in Lead Pipes** for the conveyance of water are usually "wiped" as already explained. Lead pipes are also joined by what are termed "clear-bore" joints (fig. 291), which obviate the risk of diminishing the bore of a pipe by a badly formed wiped joint. Brass ferrules or lining pipes, a few inches in length, of an internal diameter equal to that of the pipes to be joined, and suitable either for a straight pipe or for one or two branches as tees or crosses, are made use of. The ends of the pipes to be joined are slightly opened out, so as to admit the ends of the ferrules, and to afford a key and space for the solder, which is run in in a molten state after the

joint has been enclosed in a mould, until the space is filled up. This forms a very neat and strong joint.

Lead pipes can be connected without the use of solder by means of the improved unions or cone joints manufactured by various firms. In Messrs. J. Stone & Co.'s joint (fig. 292) brass unions (BB) are slipped over the ends of the pipes to be joined, and the mouths of the pipes are opened out by means of a brass or boxwood tampin; the double-cone piece (C), which

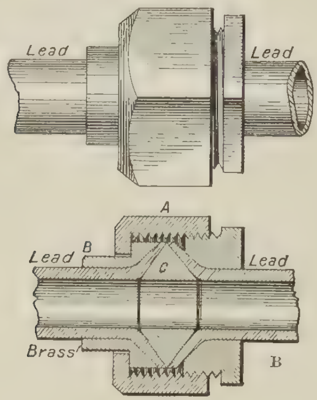


Fig. 292.—Stone's Unions or Cone Joints for Lead Pipes

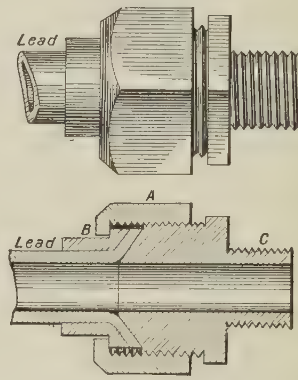


Fig. 293.—Stone's Unions or Cone Joints for connecting Lead and Iron Pipes

should be of the same internal diameter as the pipes, is then inserted, and the joint screwed up, as shown in section at A. This makes a perfectly sound joint, which can be put together single-handed in a few minutes.

**Joints between Lead and Iron Pipes.**—A somewhat similar joint is used to connect a lead with a wrought-iron pipe without solder (fig. 293). One portion of the union, C, is screwed into the iron pipe, whilst the other, B, is passed over the end of the lead pipe, which is opened out as before, and then the two parts are drawn tightly together by the special nut A.

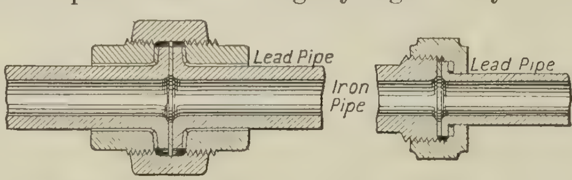


Fig. 294.—Special Joints, Lead to Lead and Lead to Iron

Fig. 294 shows other methods of connecting lead to lead and lead to iron pipes without solder.

**Weight of Lead Pipes.**—The thickness, and consequently the weight, of lead pipes used for water supply should be regulated by the pressure of water they are intended to bear. The various water companies usually specify the strength and weight of the lead pipes to be used. These vary within certain limits according to the pressure or head of water existing on the main.

The following table shows the weights per yard run of the various

sizes of lead service pipes authorized for use in the undermentioned towns:—

| Town. | Internal Diameter in Inches | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $\frac{3}{8}''$ | $\frac{1}{2}''$ | $\frac{5}{8}''$ | $\frac{3}{4}''$ | 1″ | $1\frac{1}{4}''$ | $1\frac{1}{2}''$ | 2″ |
| Aberdeen ... | — | 7 | 9 | 11 | 14 | 18 | 24 | — |
| Aldershot ... | 5 | 7 | 9 | 11 | 16 | $22\frac{1}{2}$ | — | — |
| Brighton ... | $4\frac{2}{5}$ | $5\frac{3}{5}$ | $6\frac{3}{5}$ | $7\frac{4}{5}$ | $12\frac{2}{5}$ | 15 | — | — |
| Dublin ... ... | 5 | 6 | $7\frac{1}{2}$ | 9 | 12 | 16 | — | — |
| Glasgow .. | — | 7 | — | 11 | 16 | $22\frac{1}{2}$ | 30 | — |
| London... ... | 5 | 6 | $7\frac{1}{2}$ | 9 | 12 | 16 | 21 | 28 |
| Manchester ... | 5 | 6 | — | 9 | 12 | 16 | 21 | — |
| Newcastle ... | — | 7 | 9 | 11 | 16 | $22\frac{1}{2}$ | — | — |

The weights quoted above are for what are sometimes described as "strong" and "extra strong" lead pipes, and in some specifications no weights are given, but the pipes are described as "extra strong", "strong", "middling", or "light", as the case may be. These terms, however, are now too vague, as there are many different weights of pipe of the same diameter, and it is always best to state exactly the weight per yard which is required.

Lead pipes from $\frac{1}{2}$ in. to 1 in. diameter are made in lengths of 15 ft., or in coils of 60 ft., and from $1\frac{1}{4}$ in. to 2 in. in lengths of 12 ft., or in coils of from 40 to 50 ft.

**Walker's Patent Tin-lined Wrought-iron Pipe**, known as the "Health Water Pipe" (fig. 295), has been used to a great extent during the last few years, and is strongly recommended by the medical faculty. Several corporations supplying water which has a solvent action on lead, will allow no other kind of pipe to be connected to their mains. The pipes have an inner tube of block-tin, and are jointed by means of collars having right- and left-hand threads cut in them, so that the ends of the pipes can be drawn together.

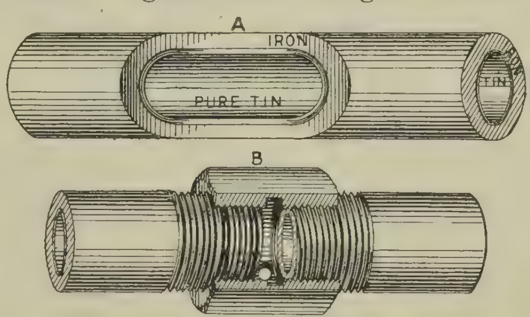



Fig. 295.—Walker's Health Water Pipe
A, Pipe; B, Vented coupling.

To prevent the possibility of a portion of the interior of the collar being exposed to the water, through the ends of the pipes not being drawn tightly up against each other, a new form of vented coupling has been introduced (B, fig. 295). This collar has a groove formed round the interior, and a small hole through the collar from this groove, so that if the abutting pipes are not drawn firmly against each other the joint will leak. The water-tightness of the joint will show that it has also been made rust-proof, no portion of the iron being exposed to the water.

Tin-lined elbows, tees, and crosses for branches and other fittings are

supplied of the various sizes required. As a protection against frost these pipes can be supplied with non-conducting material inserted between the lining and the outer tube.

**Tin-lined Lead Pipes.**—To prevent the water from being contaminated, lead pipes are sometimes protected by a coating or lining of tin. Pipes formed of pure tin may be considered above suspicion, but their cost would be prohibitive under ordinary circumstances and they would be less pliable than lead pipes.

Whilst retaining the pliability of the lead pipes, efforts have been made to tin them by drawing them through a bath of molten tin, or to coat the interior surfaces whilst the pipe is being made, but this superficial washing is soon destroyed and removed by exposure to the atmosphere, by the friction of the water passing through, and also in making the soldered joints.

Experiments have shown conclusively that such pipes are absolutely valueless in preventing the action of moorland water on the lead, for there was found to be no difference in any way between the action of the water on this and on the ordinary lead pipe. Electro-plating lead pipes with tin has also been tried, but with no better success.

**Lead-encased block-tin pipe** is much more satisfactory, and consists of a distinct pipe of pure block tin encased in a lead pipe, the union of the two metals being so intimate that no amount of bending or twisting can separate them. Experiments carried out by Mr. David Kirkcaldy show that it will sustain a greater internal pressure than a lead pipe of nearly double the weight per yard. This "lead-encased block-tin pipe" possesses all the physical qualities of lead pipe, and affords thorough protection against lead poisoning.

Owing to the great difference in the melting-points of lead and tin, it is difficult even for a very careful plumber to form an ordinary wiped joint in the lead-encased pipe. Lead melts at about 612° F., whereas tin melts at 442° F., and consequently the application of hot solder to the outside of the lead pipe in forming the wiped joint (unless it is very carefully manipulated) may cause the tin pipe to melt and run before the lead is in a condition to form a proper joint. Hence there is danger that, even if no part of the lead is exposed to the action of the water, the bore of the pipe may be slightly reduced.

A strong and neat joint can be made without affecting the tin lining by the employment of a copper "bit", but a better joint can be made by means of a thin tube of brass or copper, 2 or 3 in. long, and of the proper diameter, well tinned all over, and inserted half its length into the end of each pipe in a somewhat similar manner to that shown in fig. 291. The ends of the pipes to be joined should be evenly cut and then drawn close together over the inner tube, when the joint should be wiped in the usual way. The tin lining, as it melts, cannot get away, but amalgamates with the lead outside, and thus forms a strong joint without affecting the bore of the pipe.

Certain mechanical joints or couplings (fig. 296) have also been introduced, somewhat similar to those used for connecting lead pipes as already explained, and are specially adapted for joining the lead-encased

tin pipes, as they afford means of absolutely preventing the contact of water with the lead. The ends of the pipes AA are passed through the nuts BB, and then slightly expanded by means of the tampin, after

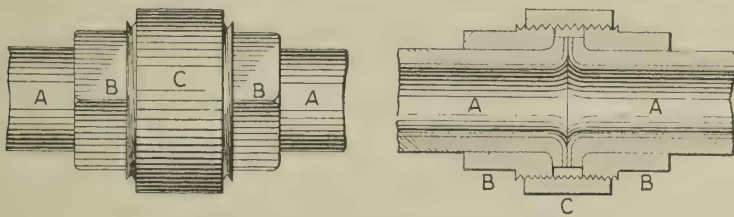


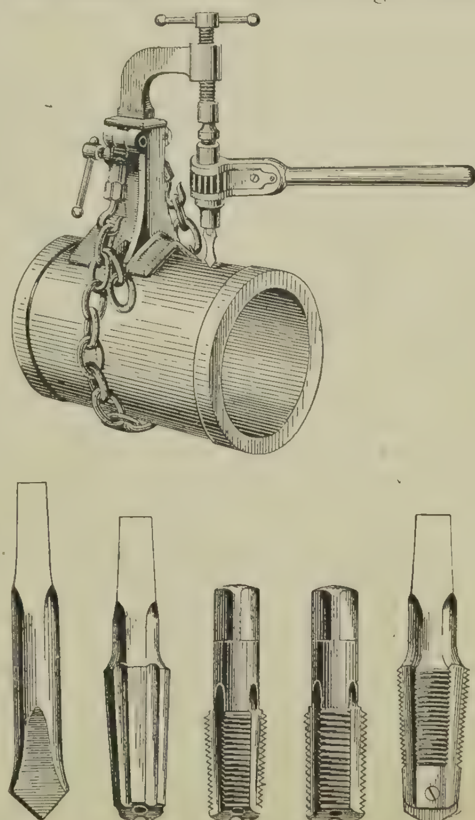

Fig. 296.—Joints in Lead-encased Block-tin Pipes

which they are laid over or tafted back with a flat-faced hammer, so as to form flanges. The band C is then screwed on, and the flanged ends of the pipes are drawn tightly together with a couple of spanners.

Pipes made from **an alloy of tin and lead** are also used as a preventative of lead-poisoning, but it is questionable whether they are thoroughly effective. Lead pipes alloyed with 3 per cent of tin were, however, said to be proof against the action of the soft Vartry water supplied for use in Dublin.

**Walker's Patent Insulated Lead-encased Health Water Pipe** differs from the ordinary lead-encased block-tin pipe in being insulated (between the two metals) with a non-fibrous heat-resisting material, which contains no asbestos, fibrous, or other pulpy material. The joints can be soldered without melting the lining.

The salient features of this tube are indelibly printed on four sides with stars, marking exactly every foot throughout the whole length of the roll, so that, after it is once fixed, it cannot be mistaken for ordinary lead or tin-lined lead pipes. It is as pliable as ordinary lead piping, and, being made on the same system as the tin-lined iron tubing, amalgamation of the tin with the lead is said to be impossible.



Drill Rimer Taper Tap Plug Tap Drill Rimer Tap

Fig. 297.—Drilling Main

**Tapping Mains.**—In laying on a water service from a main to a building, it is generally necessary to shut off temporarily the supply in the main

whilst the connection is being made. The main should, with as little delay as possible, be drilled and tapped, the ferrule inserted and jointed up to the communication pipe, which should have a stop valve fixed on

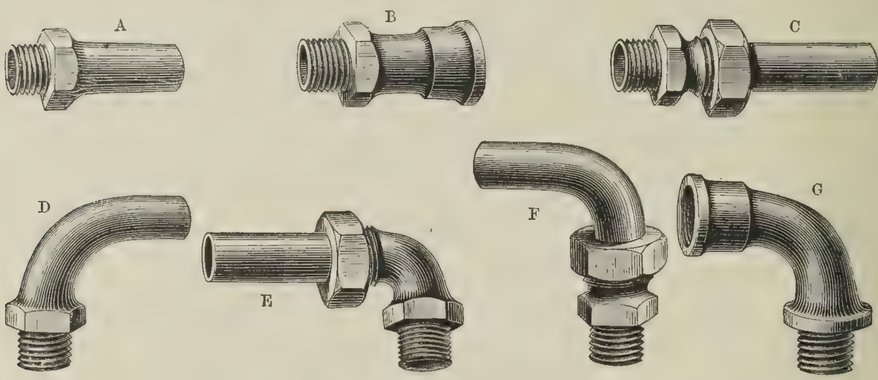



Fig. 298.—Ferrules for connecting to Mains, &c.

A, Straight ferrule for lead pipe connection; B, Straight ferrule for iron pipe; C, Straight ferrule with ground union for lead pipe connection; D, Bent ferrule for lead pipe connection; E and F, Bent ferrules with ground unions for lead pipe connections; G, Bent ferrule for iron pipe connection.

it, on closing which the water can again be turned on in the main. Fig. 297 shows the ordinary method of drilling the main, when the pipes are empty, by means of a ratchet brace, with drills, rimers, and taps of the required diameter.

Various forms of ferrule for screwing into mains are shown in

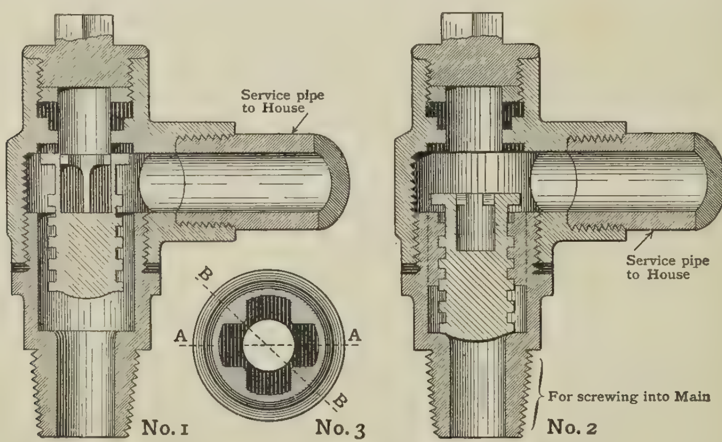



Fig. 299.—Morris's Ferrule

No. 1, showing plug valve open; No. 2, showing plug valve closed; No. 3, plan of ferrule.

fig. 298. They may be of iron or brass, straight or bent, screwed at both ends, or screwed at one end and tinned at the other, according as they are required for connecting iron to iron, brass, or lead pipes. Ground union joints, suitable for connecting iron or brass and lead pipes without the use of solder, are also shown. The joints between the lead pipes and

the tinned ends of the brass ferrules should be "wiped" if the ground union joints are not used.

**Tapping Mains under Pressure.**—The operation of tapping the main is more complicated when it has to be carried out with the mains under pressure, but there are various apparatus available for this purpose. They are sometimes termed screw-down angle, or stop-valve ferrules, special cast-iron covers being provided for them. Amongst others, Morris's ferrules are very effective, and afterwards serve as stop valves, which can be opened and shut as required. Nos. 1 and 2, fig. 299, show sections (when open and shut) of one of Morris's ferrules for inserting in a main under pressure. The four projections shown on the plan of the ferrule (No. 3) have threads cut in them to receive the plug-valve. These threads are seen in section in No. 2, which is taken on the line BB; the section No. 1 is on the line AA, and shows the ports through which the water passes to the service pipe, when the plug valve is unscrewed from its seat. The makers supply special apparatus for drilling and tapping the mains under pressure. Fig. 300 shows an ordinary form of screw-down ferrule stop tap.

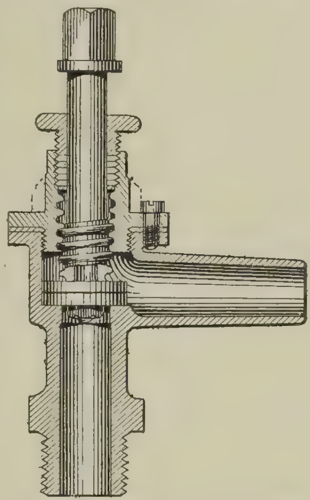


Fig. 300.—Screw-down Ferrule Stop Tap

**Hack's Connector or Stop-valve Ferrule** (fig. 301) has a self-acting loose valve A, arranged so that the pressure of water in the main keeps it open, the elastic collar B being tightly pressed against the upper seating, thus ensuring soundness. In the illustration the valve is resting on the lower seating, the main being empty. When it is desired to cut off the supply to the house for any purpose, the cap C on the top of the ferrule is unscrewed, and the detached metal plug D dropped into the opening above A, and upon screwing the cap down to its original position it presses the valve spindle down until the valve rests on its seating and closes the orifice. When the supply is again required for the house, the cap is unscrewed and the plug removed, when the pressure of the water in the main will press the loose valve upwards and so restore the communication.

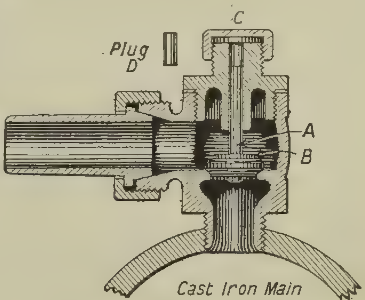



Fig. 301.—Hack's Ferrule or Connector

# CHAPTER VII

## WATER-METERS

Water, when supplied for purely domestic purposes, is generally charged for by a rate on the house property; but when supplied for manufacturing or trade purposes, it is usually charged at so much per thousand gallons, the quantity being measured by a meter. Water-meters are either positive or inferential in their action. Most of them are "high-pressure", that is, they are so constructed that the water in passing through them loses but

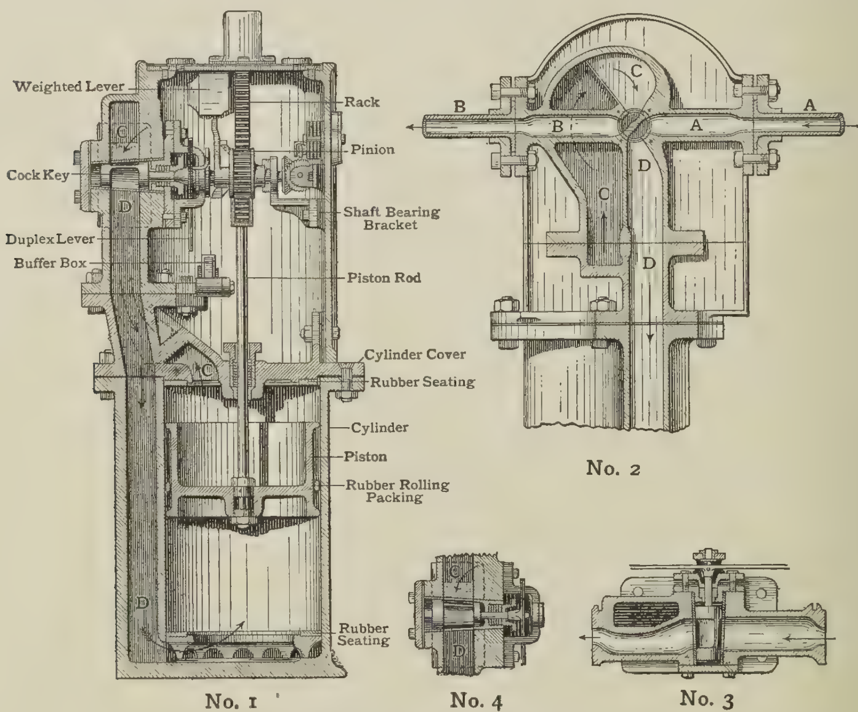



Fig. 302.—Kennedy's Patent Water-meter

No. 1, Vertical side section; No. 2, Vertical section of cock key and water passages; No. 3, Horizontal section of inlet and outlet passages; No. 4, Alternative form of tapering cock key.

a small portion of its pressure, and consequently they will measure the quantity passed through when fixed at a lower level than (or at a distance from) the point where the water has to be delivered.

The **Positive** or **Direct-action Meters**, such as "Kennedy's" (fig. 302), measure the quantity of water passed through them by recording the number of times a cylinder of known capacity is filled and emptied, the water being admitted alternately above and below a piston by means of a four-way cock, which directs the water to the upper or lower side as it reaches the end of its stroke. The upper end of the piston rod passes

through a stuffing-box in the top of the cylinder, and terminates in a rack working on a pinion, which records by wheel-work the number of strokes made by the piston, and the dial face is arranged to register the number of hundreds, thousands, tens of thousands, hundreds of thousands, &c., of gallons passed through. The pressure of the water causes the piston to rise and fall, and a weighted lever, actuated by the rack on the piston spindle, moves the four-way cock at the end of each stroke.

No. 1 (fig. 302) shows a side section through the centre of the shaft, cock key, and piston; No. 2, a front section of the cock key and water passages; and No. 3 a horizontal section through the centre of the inlet and outlet. The piston is shown in the position of having nearly completed its upward stroke. The water enters at the inlet A, No. 2, and is directed by the cock key down the passage D to the bottom of the cylinder shown in No. 1, forcing up the piston, which presses the water (which, on the previous down stroke, entered above the piston) up through the passage C into the outlet passage B. When the piston has moved up a little farther, the weighted lever passes its centre of gravity and falls on the key arm, or duplex lever, sending it down till it is stopped by the buffer box. This buffer is faced with india-rubber, and, travelling in the same curve, gradually brings the weighted lever to rest. The key will then be at right angles to the position shown in No. 2, and the water will be directed from A, down C, into the top of the cylinder, forcing the piston down, while the water admitted below during the last up stroke is forced up the passage D and out by the outlet B. When the piston has nearly reached the bottom of the cylinder, the rack-pinion lifter will have lifted the weighted lever from the left side of the buffer box and raised it to a vertical position, and from there it will have fallen on the right-hand key arm, and have brought back the cock key to its former position, ready to begin another upward stroke.

The noise made by the weighted lever, as it is thrown over from side to side, is rather objectionable, and the larger sizes have a tendency to knock themselves to pieces when working at a high velocity. These defects have been partly remedied by recent improvements applied to 2-inch and larger meters, by which the noise of reversing has been lessened and the weight of the hammer reduced. The principal modification is that, just before the hammer reverses, a clutch gear comes into action and moves the quadrant, so that the hammer falls on the quadrant in motion instead of at rest.

The piston is now made of vulcanite, instead of metal as in the older patterns, and its accuracy of fit and freedom from friction are secured by a ring washer of india-rubber, which rolls between it and the sides of the cylinder as it moves up and down. This ring wears, and requires to be renewed occasionally. The vulcanite piston, being about the same specific gravity as water, reverses more easily and works more smoothly than the metal one. Each end of the cylinder is fitted with an india-rubber seating, on which the piston forms a water-tight joint, if back pressure forces it to either end.

The meter is made in twelve sizes, ranging from ¼-in. to 8-in. bore,

and capable of delivering from 600 to 100,000 gal. per hour. One advantage this type of meter has over some of the other patterns is that repairs can be carried out on the spot.

The cylinders of meters used for measuring any water which oxidizes iron rapidly, and all those measuring small supplies, should be brass-lined, and the working-parts, consisting of the buffer box, rack-pinion, and cock gland, should be of gun metal.

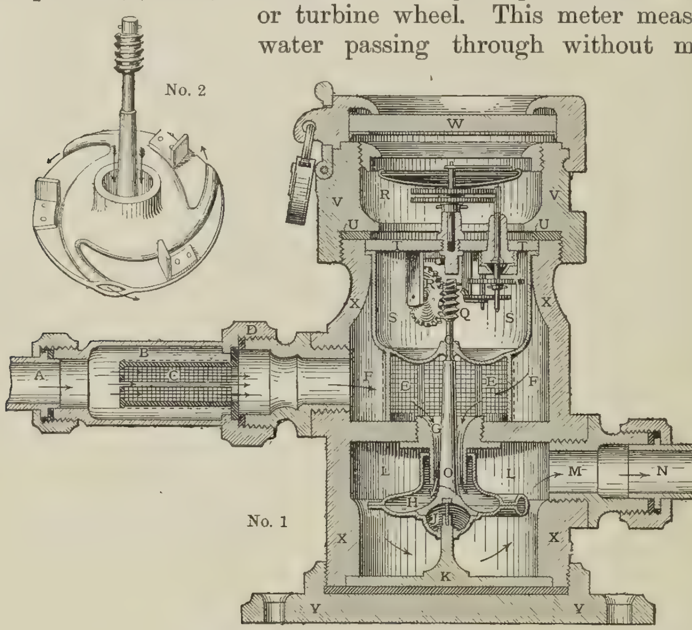



Fig. 303.—Siemens's Patent Water-meter

No. 1, Vertical section; No. 2, View of drum and vanes, &c.

With the **Inferential Meters** the quantity of water passing through them is inferred from the movement of a revolving wheel or disc, as in Siemens's patent (fig. 303), which acts on the principle of the Barker's Mill or turbine wheel. This meter measures the water passing through without materially diminishing its velocity or effective pressure. The cast-iron case X, which forms the body of the meter, is formed into an upper and lower chamber; the water first passes through a filter or copper strainer E, in the upper chamber, to prevent foreign substances from passing into the working parts, and is then directed down into the interior of the revolving drum H, through a conical opening G, formed round the spindle O, on which the drum revolves. A view of the drum and spindle is shown in No. 2. The drum is formed of stout brass, stamped to proper curves, and riveted and soldered together so as to form curved channels to convey the water from the centre to its outer edge. The spindle turns on a steel foot pin working in oil at J, and by means of an endless screw Q, on its upper extremity, actuates the wheel-work R, by which the number of revolutions and the quantity of water passed through are registered on the dial above. The water escapes through a series of openings in the outer

periphery of the drum, in a direction which causes the latter to revolve, and at each revolution a known quantity of water is discharged.

As the velocity of the water passing through would vary, the simple revolution of the drum would not of itself correctly measure the quantity passed through, but this is compensated by the vanes attached to it (No. 2) being so formed as to offer a resistance which increases as the square of the velocity, and by this means a balance of power is obtained, and the number of revolutions is constant, under varying pressures, for similar quantities of water passing through the meter.

Siemens's meters are made in fifteen different sizes, the inlets and outlets ranging from $\frac{3}{8}$ in. to 12 in., and the rate of delivery from 150 to 90,000 gal. per hour at an effective head of pressure of 150 ft. The smaller sizes, from $\frac{3}{8}$ in. to $1\frac{1}{2}$ in. inclusive, are usually supplied with strainers of brass, fixed horizontally on the inlet side (C, No. 1), while for the larger sizes, or from 1 in. upwards (if ordered), a cast-iron dirt box, fixed vertically and containing a copper strainer, is provided. The strainers can be obtained with unions, tinned for lead, or screwed for iron pipes, and the dirt boxes with flanged ends for connecting to cast-iron pipes.

**Repairs.**—It is customary to return these meters periodically to the makers for the purpose of cleaning, repair, and subsequent adjustment, but, as that would be very inconvenient when fixed abroad, the makers supply (to order) the parts most usually required in repairing. Skilled labour and proper mechanical appliances are required for taking the meter to pieces, putting together, and testing.

**Portable Meters** of various patterns are also obtainable for measuring water supplied for shipping, street-watering, sewer-flushing, and other temporary purposes. They can be used with stand pipes or connected to hydrants of various patterns.

**Full-bore Meter.**—As the ordinary form of meter, when attached to a pipe of its own diameter, restricts to a considerable extent the amount of water passing through it, Messrs. Guest & Chrimes now manufacture what they term a full-bore meter. This meter has an area throughout equal to the terminal area of its inlet and outlet, and of the pipe to which it is connected, and therefore admits of the passage through it of a volume of water as nearly as possible equal to the area of the pipe, and at a much less cost than by the use of a larger size of the ordinary meter. Allowance has to be made in all meters for the friction caused by the curves in the meter itself.

**Improvements in Design.**—Up to a few years ago the chief meters in use were those of the positive type, as Kennedy's, and the inferential class, as Siemens's, already described. The conditions of modern water supply, however, together with the public demand for high pressure and constant supply, have led to many improvements in the design of meters. The cost has been considerably reduced by the use of special machinery, and the interchangeability of the various parts has been ensured by the use of hardened-steel gauges.

The conditions generally laid down by waterworks engineers are that a water-meter should be of such construction and material as to defy the action of corrosive water, of such a form as to allow of the various im-

purities, to which at times water is exposed, passing freely through its mechanism, and that its parts should be readily interchangeable, and its cost moderate. To guard against the action of corrosive water in the smaller meters, all the parts exposed to the action of the water are made of phosphor bronze, brass, or gun metal, whilst in the larger sizes all the working parts are of the same metals. To allow of the free passage of impurities, the casing is made simple in form, with no recesses for dirt to accumulate, and a clear and sufficient waterway in all directions. The interchange of parts is effected by all the meters being made and gauged to $\frac{1}{1000}$ in.

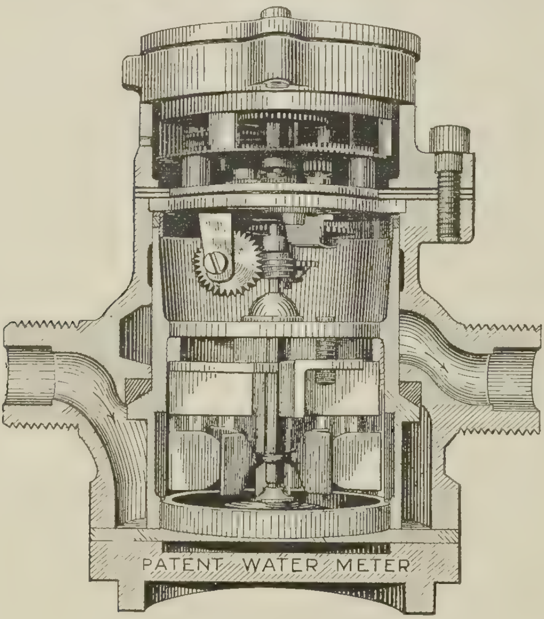


Fig. 304.—Tylor & Sons' Patent Rotary Water-meter

One result of this accuracy of manufacture is that by turning the meter round, and removing the bottom flange, the internal case, containing the working parts, can be removed and exchanged without disturbing the connections with the communication pipe, a great advantage when the meter is fixed below the level of the ground.

**Rotary Water-meter.**—One form of inferential meter, patented by Messrs. J. Tylor & Sons, is that known as the "Rotary Water-meter" (fig. 304). It is made in all sizes, from $\frac{3}{8}$ in. up to 12 in. The water flows freely from inlet to outlet without a check, turning in its passage a fan, the spindle of which has a worm gearing with counter above. The water passes through the inlet into the space surrounding the fan case, and two slots in the side of this inner case direct the flow of water almost tangentially on to the vanes of the fan, the tips of the blades of which almost touch the fan case, so that no current can pass. After striking the vanes, the water rises and passes through ports on its way to the outlet branch. At intervals there are corrugations cast in the case behind the vanes, forming vortex chambers, which act as brakes, ensuring a wide range of accuracy, and bringing the fan to rest directly the flow of water ceases. Radial ribs with horizontal projections are arranged in the large space between the upper side of the fan and the top of the case in which it revolves, and these ribs deflect a portion of the outflowing water back to the blades, the action being greater as the velocity of the flow increases. This arrangement is found to be most valuable in rendering the meter accurate, both at high and low velocities.

The fan is formed of phosphor bronze, and is carefully balanced, the blades being twisted in opposite directions to avoid upward or downward thrust. The whole of the fan mechanism is enclosed within the brass case, which can be readily removed from the body of the meter, without disturbing the water connections, by detaching the bottom plate and drawing it out. In replacing the inner casing (either old or new) it is only necessary to see that the india-rubber ring, which is triangular in section, is in its proper place in the outer casing before pressing the inner casing into position. The cone bearing compresses the india-rubber as the screws in the bottom

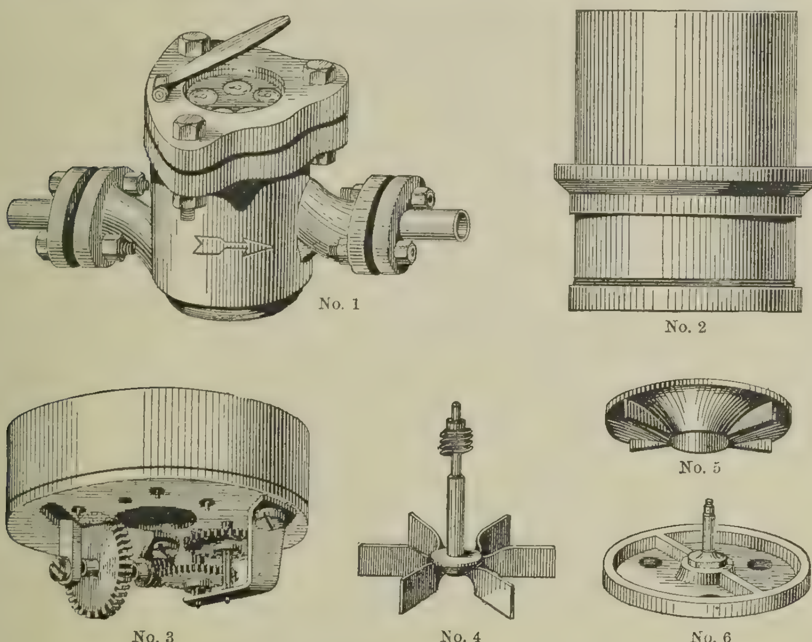



**Fig. 305.—Tylor & Sons' "Household" Water-meter**

**No. 1, View of meter and connections; No. 2, Inner case and cap; No. 3, Gearing for dial; No. 4, Fan and spindle; No. 5, Brake; No. 6, Toe piece.**

plate are tightened up. The screwing-up must be continued until the worm gears without friction with the clockwork of the dial.

Messrs. Tylor & Sons manufacture two other forms of small meter, which (they claim) will register as accurately as any positive meter, and are very much cheaper. Being extremely sensitive, they are particularly suitable where there are only small flows to register, such as on the pipes supplying houses which have supply cisterns fed through ball valves. They are known as the "Household" and "Parvus" meters.

**The "Household" Water-meter** (fig. 305) is suitable for domestic supply, and can be obtained in four sizes, ranging from $\frac{3}{8}$ in. up to 1 in. It is very sensitive, and friction is reduced to a minimum, as there is no stuffing-box between the water space and the clock-work, and the clock-work and dial are under pressure, the dial being kept clean by a current of water passing

over it. This meter has been adopted by the town of Naples, where there are said to be a greater number of meters fixed than in any other town in the world.

**The "Parvus" Water-meter** is made in one size only, and will pass about 2400 gal. a day, which is ample for the requirements of any ordinary house. It is made throughout of brass, gun metal, and phosphor bronze, and its parts are interchangeable. When a quantity of water is required quickly, as for baths, it would, of course, be drawn direct from the supply cistern, whilst a branch from the communication pipe could be provided for the supply of drinking water.

**Other Varieties.**—There are many other forms of water-meter in the market, among which may be mentioned the "Bee" disc meter, supplied by Messrs. Ham, Baker, & Co. It is of the positive type, constructed entirely of bronze, and can be fixed in any position or at any angle to suit the supply pipe. Kent's meters are of three distinct types, and are very reliable. The "Standard" and "Uniform" are positive meters, the former for house-supply and small-flow purposes, and the latter for trade and municipal supplies. The "Venturi" meter (Herschel's Patent) is most suitable for the measurement of water under pressure in mains of over 6 in. in diameter. There are no moving parts in contact with the water, and they offer no obstruction, nor cause any deviation in the line of pipes.

**Reading the Dials of Water-meters.**—Dials of water-meters, like those of gas-meters, are easily read, if attention is paid to the direction in which each set of figures runs, as these are not always arranged on the same system. One set of circles is figured in the same direction as the hands of a watch, whilst the alternate ones run in the opposite direction. The point to remember is only to note and set down the figure which each hand has *passed.*

A, fig. 306, shows the usual arrangement of dials for Kennedy's Positive Meter, the separate figured circles from the right being marked hundreds, thousands, tens of thousands, hundreds of thousands, and millions. Meters for small consumers may not go beyond the third or fourth circle. In setting down the reading as indicated by the hands in the figure, it is immaterial whether it is taken from the right or left.

| | |
|---|---|
| In the circle on the right showing "hundreds", the hand is on the figure 3, which indicates 300 gal. ... ... ... | 300 |
| In the second circle the hand has passed the 6, the reading being | 6,000 |
| ,, third ,, ,, ,, 8, ,, | 80,000 |
| ,, fourth ,, ,, ,, 5, ,, | 500,000 |
| ,, fifth ,, ,, ,, 6, ,, | 6,000,000 |
| Or, reading from left to right in the reverse order gives the same result (in gallons), viz. ... ... ... ... ... ... | 6,586,300 |

B, fig. 306, shows the dial of a Siemens's Inferential Meter, registering up to 1,000,000 gal. It will be observed that there are three circles, each figured separately and alternately in contrary directions. The outer circle is divided into 100 equal parts of 10 gal. each, so that one revolution equals 1000 gal. The readings are taken on this circle from the position of the

fixed pointer, which is now 250. The inner large circle is divided into 10 equal parts of 10,000 gal. each (or, by utilizing the subdivisions on the outer circle, into 100 equal parts of 1000 gal. each), so that one revolution equals 100,000 gal. The readings on this circle are taken from the large hand, which has just passed the middle division between 10 and 20, thus reading 15, or 15,000. The small inner circle is divided into 10 parts of 100,000 gal. each, so that one complete revolution equals 1,000,000 gal.

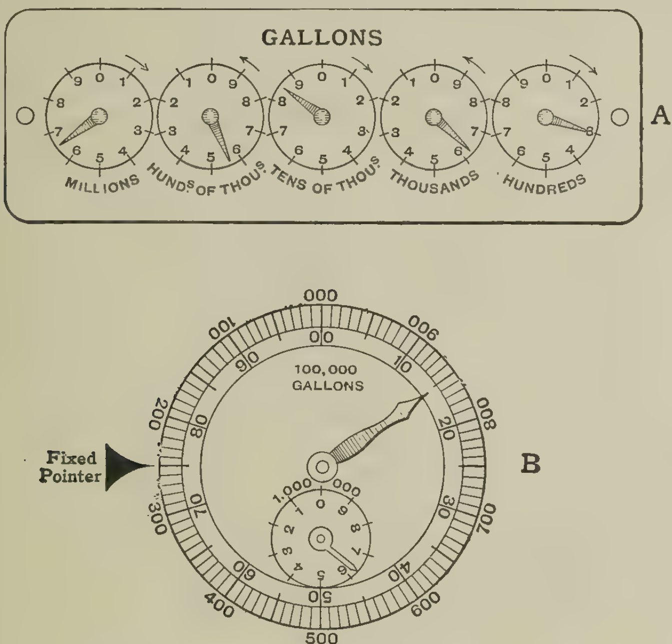



Fig. 306.—Two Water-meter Dials

The small hand has passed the figure 6, the reading being 600,000 gal. The complete reading would be:

| | |
|---|---|
| On small dial by small hand ... ... ... | 600,000 gal. |
| Inner large dial, large hand ... ... ... | 15,000 „ |
| Outer large dial, fixed pointer ... ... ... | 250 „ |
| Total ... ... | 615,250 gal. |

**Deacon's Waste-detecting Meters** fixed on mains register continuously the quantity of water passing through, by means of a pencil which marks on a graduated sheet of paper coiled round a drum actuated by clockwork. The drum revolves once in every twenty-four hours, and the movement of the pencil is controlled by a disc which is raised and lowered by the varying flow of water. The diagram for each twenty-four hours forms a record for future reference, and a careful inspection will show whether there is any considerable leakage or waste going on. When no water is flowing, a horizontal line will be marked along the top of the sheet, whereas with an irregular flow a zigzag line will be recorded, and with a uniform flow a

horizontal line, but both below the normal. If a steady consumption is recorded during the early morning hours, when there is usually very little demand for water, it indicates that waste is going on somewhere, which may be due to defective fittings or leaky mains. To find the district in which the waste is taking place certain sluice valves controlling sections or wards are closed and fresh readings taken until the defective main or branch is traced. To localize the spot an instrument termed a stethoscope is used, the vulcanite end of which is placed against the pipe (by opening the stop-cock boxes), and the other end to the ear, when if any water is passing it will be distinctly heard. When the defects have been made good the test should again be applied.

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# CHAPTER VIII

## BRANCH SERVICES

**Sizes of Pipes.**—It is not necessary, in a house, to make provision for an ample supply of water being drawn at all the draw-offs at the same instant, but each fitting should have a pipe and tap of sufficient capacity to deliver a certain amount of water in a reasonable time.

The size of the rising main, or service from the company's main, will depend on circumstances. Certain water companies stipulate the size they allow, and usually the pipe must be of lead of a certain weight, at any rate up to the point on the consumer's premises where it begins to ascend.

If the supply is intermittent, and available only during certain hours of the day, the rising main should be large enough to charge the whole of the storage cisterns in the time. Pipes of 1 in. or $1\frac{1}{4}$ in. would be sufficient for ordinary houses, and $1\frac{1}{2}$ in. or 2 in. for high or large buildings.

If the supply is constant, $\frac{1}{2}$-in., $\frac{3}{4}$-in., or 1-in. pipes will be ample, depending to a certain extent on the height of the cisterns or draw-offs above ground and the pressure available from the main itself.

If the building is fitted with fire hydrants, the rising main should not be less than 3 in. in diameter to the point where the top hydrant is fixed, above which it would be continued to the cistern at a reduced size. The 3-in. pipes should be of cast-iron, with flanges for the convenient attachment of the hydrants. A bend with foot-rest, sometimes known as a "duck's-foot" bend, should be bedded on concrete at the foot of the rising main in order to support it firmly.

The main supply pipe from the cistern may require to be $\frac{3}{4}$ in., 1 in., $1\frac{1}{4}$ in., or $1\frac{1}{2}$ in. diameter, but may be diminished as the various branches are taken from it. Baths should have $\frac{3}{4}$-in. or 1-in. pipes; lavatory basins, water-closet cisterns, and feed cisterns to small side boilers, $\frac{3}{8}$-in. or $\frac{1}{2}$-in.; and sinks, draw-offs, and drinking-water taps, $\frac{1}{2}$-in. or $\frac{3}{4}$-in.

**Course of Pipes.**—The direction of the water-service pipes should be very carefully considered before commencing to fix them. The positions of all the points at which water has to be delivered should be marked on the plans of the various floors; also the position of the cistern, if there is one.

The supply pipe to the cistern, termed the "rising main" or the "communication pipe", should be taken as direct as possible from the main outside to the cistern, entering the house at a sufficient depth to be safe from the effects of frost, and then carried up vertically. Where practicable, the pipe should be fixed against an inner wall, and well away from all windows or external openings, so that it will not be exposed to frost.

From the stop cock, which is fixed close to the cistern to control the cold-water fittings, the main supply pipe should be led in a direction from which most of the branches are required, either along the roof above the ceiling joists (vertical branches being carried down to the various fittings), or it may at once be carried down through the ceiling against an inner wall, and horizontal branches taken off right and left as required (see Plate XIV).

**Means of Emptying Pipes.**—All pipes conveying water, either as mains outside or as service pipes inside buildings, should be laid at such a fall as to be capable of being emptied at certain points when they require cleaning out or repairs. Mains are emptied by means of "wash-out" or "scour-out" valves, which are fixed at their lowest points, and are opened when the sluice valves at the ends of the section to be emptied are closed.

House pipes should also be so fixed that the water contained in them can be run off, either from any branch by closing its particular stop cock, or from the whole system by shutting the stop cock close to the cistern and opening the various taps at the extremities of the branches.

The rising main can be emptied by a draw-off tap fixed at its lowest point. In a house having a basement or cellar, this can usually be easily arranged if the stop valve is fixed there. One has simply to shut the valve connected with the main, and open the tap, which, of course, must be fixed on the house side of the stop valve. The water in the rising main to the cistern will then drain away; and, when there is no storage cistern, that contained in the various branches should also be drained off, partly through the tap referred to, and partly through the taps fixed at the ends of the branches.

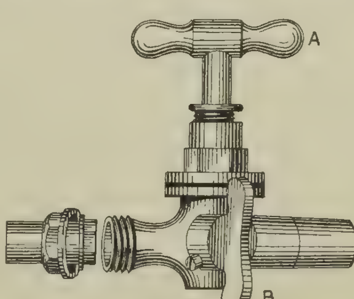

Fig. 307.—Garratt's Patent Emptying Stop Cock

Where the stop cock which shuts off the supply to a house from the main is in a pit underground, a small tap, termed a "weep tap", is sometimes screwed into the side of the stop cock on the house side of the valve. When the stop cock is shut off, this weep tap should be opened, when the water in the rising main will run out.

**Garratt's Patent Emptying Stop Cock** (fig. 307) is sometimes used for this purpose. When the stop cock A is shut down, stopping the supply to the house, the small tap B is opened a half turn, and the water in the rising main will escape.

To prevent waste care must be taken to shut these weep taps when the water is again turned on.

**Fixing Pipes.**—All water pipes in a building should be securely fixed and retained in position; wrought-iron hold-fasts or pipe hooks (A, fig. 308),

driven into the joints of the walls or into the timbers, are often used for the purpose. Wrought-iron brackets are sometimes used, according to the positions occupied by the pipes. Special care is required at the angles, or where the pipes change direction, as the constant vibration caused by the water being shut off suddenly is liable to work the pipe hooks loose. Malleable-iron clips (B, fig. 308) are also used for fixing wrought-iron pipes clear of the walls. They are neat in appearance, and allow the pipe to be removed without withdrawing them from the wall.

Lead pipes require careful fixing to prevent their capacity being reduced by the hold-fasts being driven too hard up against them, and, when laid horizontally, they should be supported at closer intervals than iron pipes, otherwise they are liable to sag with their own weight and form pockets or syphons. When the sagging is sufficient to form a syphon in the pipe, so that the water cannot drain away, trouble may be experienced when the water is again turned on, owing to the air in the pipe obstructing the flow of water through it and necessitating the application of the force pump to clear it, or the water may freeze in the bend through being unable to drain away. It is a good plan to support a lead pipe throughout its length on a board or batten, as explained in Section II, p. 81.

Where pipes pass through ceilings, floors, or walls into adjoining rooms, the holes must be thoroughly made good, so that no air can pass through which might prove objectionable.

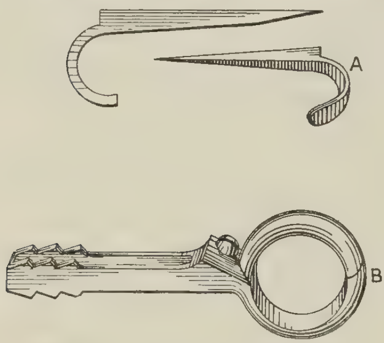

Fig. 308.—A, Pipe Hooks or Hold-fasts; B, Malleable-iron Clips.

**Protection from Frost.**—The whole of the water-service pipes in a building should be carefully protected from the action of frost. The damage and inconvenience caused through the bursting of water pipes in houses can to a great extent be avoided by a judicious arrangement of the pipes themselves, by fixing them against inner walls, well away from windows or other openings, and lagging them by means of one or more layers of felt, silicate cotton, or other non-conducting material. This is necessary even when they are fixed in chases or grooves in external walls, and is specially so in the roof, where they are much exposed, and where bursts do so much damage by flooding the house. When a pipe is fixed against an external wall, even when to be lagged and the front cased in, it is a good plan to fix a board behind it. Care should be taken that the lagging is continued round the pipes where they pass through the walls. This is frequently omitted, the hole being only made large enough to admit the pipe.

In positions where the exposed or lagged pipes might be considered objectionable in appearance, they should be cased or boxed in with wood, which can be finished to match the adjoining work. If the pipes are fixed in a chase or groove in the wall, the front casing can be fixed flush with the face of the wall: but when fixed on the face of the wall, side battens are

required as well. The front should always be fixed by means of screws and brass cups, so as to be readily removed for inspection. Sometimes the pipes are fixed in an angle, where they can be more neatly covered than where a projecting boxing is necessary. It may be found practicable to run two or more pipes in the same casing, and, as an additional security against frost, the space between the lagged pipes may (if horizontal) be filled with sawdust or other non-conducting material. Sawdust and hair felt are sometimes objected to, owing to the smell when damp or decay affects them, and the latter harbours vermin. Cocoa-nut fibre and silicate cotton are also used for packing round the pipes. When not cased in, it is a good plan to cover the hair felt with canvas before applying the tarred twine or copper binding wire.

Where there is any risk of house pipes freezing, owing to their being insufficiently protected, arrangements should be made either to keep the water in the pipes "on the move" or to shut off the supply altogether and empty the pipes, the latter being the better plan.

It is sometimes practicable to open the tap slightly at the end of a run of pipes, leaving it to drip during the night, when the slight movement of the water may be sufficient to prevent its freezing. This can only be done, however, when there is an abundance of water, and the "waste" would be of little importance. Care should be taken as to where this waste is discharged into the open air; for if the tap over the scullery sink, for instance, is left to dribble, the waste pipe from it, which usually discharges over a gully outside, is liable to be completely stopped at the outer end, owing to the gradual freezing of the dribble, and the sink eventually overflows, causing flooding and consequent damage. If the waste pipe discharges under the grating of the gully trap, and is otherwise protected by means of bags or straw, the freezing of the outlet may be prevented.

**Anti-frost Pipes.**—In the case of the ordinary house pipes, as already explained, it is easy to arrange for emptying them during frosty weather by shutting off the supply and drawing off the water contained in the pipes through the taps. A special lead pipe is made to prevent bursts, but has not come into general use; it is shaped thus  in cross section, and consequently a certain amount of expansion can take place without fracturing the pipe.

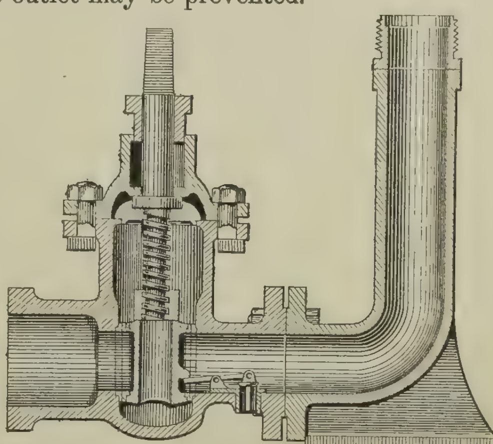

Fig. 309.—Sluice Valve Hydrant, fitted with Self-acting Frost Valve

In certain positions, however, special arrangements must be made for drawing off the standing water, such as that from a hydrant, stand post, or street watering post. When these fittings have been in use, and the sluice

valves are shut, the water which is cut off between the sluice valve and the mouth of the fitting remains, and unless this is emptied there is danger of its freezing and rendering the fitting useless until it can be thawed.

Various devices have been adopted to enable this to be done, one of which (fig. 309) is to cause the sluice valve, whilst in the act of closing, to press on one end of a short lever and depress it, the other end raising a plug from its seating in the bottom of the pipe and allowing the water to escape. When the valve is again opened the plug resumes its normal position, in which it is kept by the pressure of the water.

Another arrangement is to open this frost cock by means of a fixed tee-

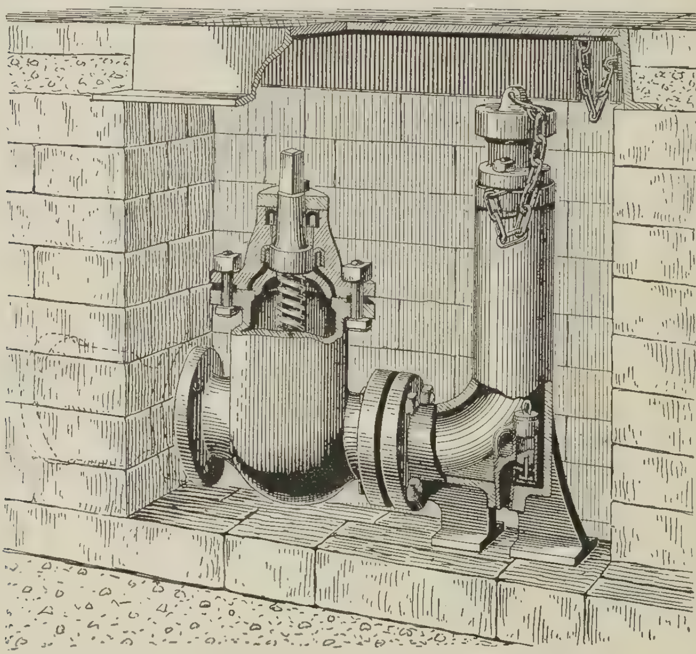

Fig. 310.—Lewis Baker's Patent Automatic Frost Valve fixed to Hydrant

spanner, but care must be taken to shut it again before turning on the water; otherwise there may be a great waste.

Lewis Baker's patent automatic frost valve, as fixed on Stone's improved "Metropolitan" hydrant (fig. 310) is an improvement on the ordinary form of frost valve, being automatic and certain in action, and, as it is readily accessible from the interior of the delivery outlet of the hydrant, it can be removed, examined, and replaced in a few minutes.

**Jones's Unfreezable Cistern-overflow Valves** (fig. 311) are attached to the inlets of overflows from house cisterns. The valve is of mica, and does not get frozen, and, as it is closed whilst in its normal position, like the flap valve which it supersedes, nothing can enter from the outside, and it opens readily as the water level rises and allows the water to escape.

**Position of Ball Valves.**—Ball valves, or ball cocks as they are sometimes termed, are fixed in the various cisterns to regulate the supply of water. They should deliver the water a few inches below the top of the cistern, and the ball and rod, or lever, should be so regulated that the supply will be cut off before the cistern begins to overflow, and that the ball will not be submerged when the cistern is full.

**Position of Stop Cocks.**—Stop cocks to regulate the flow of water through the service pipes should be fixed in such positions as to command the whole system and to admit of ample control, so that any particular section can be isolated without having to shut off the whole supply to the house, should any repair be required at a particular point.

One should always be fixed on the service or communication pipe to the house; the water companies insist on this being fixed either close to the main, in the pavement or fore-court, or just within the fence of the con-

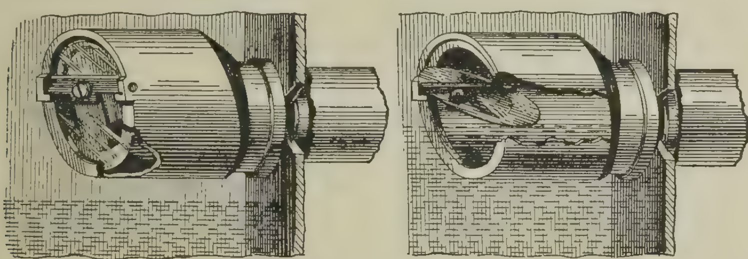

Fig. 311.—Jones's Unfreezable Cistern-overflow Valve (shut and open)

sumer's premises, usually in a pit provided with an iron cover, so as to be readily accessible for inspection, shutting off, or turning on, as required.

In some cases it is convenient to have another stop cock fixed on this pipe, close to the cistern, so that, if anything goes wrong with the ball cock or cistern, the water from the main can be shut off and the necessary repairs or alterations effected without having to go outside. This particular stop cock is sometimes fixed in connection with an air valve, which is necessary when it is desired to empty the rising main, as the water in this will not escape readily unless air can get access at the top. If sufficient water is drawn from the cistern to allow the ball to fall a little, air is admitted in this way; otherwise it may take a considerable time for the water in the rising main to dribble away.

The number and position of the stop cocks on the delivery pipes in the house will depend on where the various fittings to be supplied are situated. One should always be fixed close to the cistern on every delivery pipe leading from it, so that any or all can be shut off if required. Whilst some authorities consider that only one connection should be made to the cistern, others advocate making more than one, so that if anything should go wrong with one delivery pipe or its branches, the whole supply to the house need not be cut off.

Where, however, there is a hot-water circulating system, a separate pipe should lead direct to the boiler or cylinder, or to the feed cistern, and

this pipe should be kept quite distinct from the others, and be provided with a stop cock of its own, so as to avoid any danger of shutting off the supply to the boiler in case of repairs being required to the cold-water system. This stop cock should be fixed close to the cistern, and, to avoid any risk of the supply to the boiler being tampered with by unauthorized persons, a special form of locking cap is sometimes provided.

If there is only one connection to the cistern for the general service of the house, it should be of ample size for all requirements, and as the pressure is small the stop cock should be of the full-way pattern, and fixed as close as practicable to the cistern, so that any leakage from it will drop into the safe, from which it will escape through the waste-pipe into the open air, instead of causing damage to the ceiling, &c.

Branches from the primary supply to the various fittings should also be provided with stop cocks, as close to the primary supply as practicable, as shown in Plate XIV. This arrangement is particularly necessary where, on account of the constant supply, storage cisterns are not provided. In the best work another stop cock is fixed near each bath, lavatory, sink, &c., so that any fitting can be removed for repair or renewal without having to shut off the supply to other fittings. A similar arrangement is adopted for the hot-water supplies.

The initial cost of these stop cocks is amply repaid by the facility with which the various sections and fittings of a house can be isolated and dealt with as necessary.

Labels should be attached to each stop cock. They may be of wood, celluloid, porcelain, or metal, and may be lettered to describe the fittings they control, or simply numbered. In any case a list of all the stop-cocks, with their positions and uses, ought to be prepared by the architect or plumber, and framed and hung in a conspicuous position in the kitchen or other suitable room.

Plate XIV shows diagrammatically the cold-water supplies in a house of moderate size, with stop cocks on the main service and supply pipes and on the most important branches, and also near the principal sanitary fittings. The stop cocks are numbered to correspond with the numbers on the reference list, which is printed on the plate.

**Position of Drinking-water Taps.**—Water for drinking or other domestic purpose may be drawn direct from any tap which is fed from the storage cistern. To avoid all risk, however, of having to use water for drinking which may have become contaminated in the storage cistern, many people prefer to draw the water direct from the rising main, using that in the cistern for baths, lavatories, and other sanitary fittings.

The taps fed from the rising main should be fixed at the most convenient points, either on one or more floors, and should be treated in the same way as if there were no cistern. They should be marked "Drinking water", and a stop cock should be fixed close to the rising main on the branch on which the tap is fixed.

**Furring, &c., in Pipes.**—Service pipes, of a size slightly larger than theory might show as being necessary, should be used, not only for the supply of extra services or extensions of the system, but to provide

against the unavoidable obstructions which from time to time affect the flow of water.

Cast-iron mains may be treated with Dr. Angus Smith's solution, and wrought-iron pipes may be galvanized, but under certain conditions both sorts are liable to have the effective bore partly obstructed. This may be caused by a deposition, at certain points, of sediment contained in the water itself, which can generally be got rid of through scouring-out valves. Or the obstruction may be due to oxidation of the interior of the pipe, or to chemical deposits being formed, hard water sometimes depositing crystals of lime, and soft water a peculiar tubercular formation of oxide of iron, all interfering more or less with the passage of the water.

Another fertile source of mischief is the "furring-up" of the pipes connected with the hot-water system, especially when certain hard waters have to be used. This will be more fully considered in Section VI. Some hard waters also leave deposits in cold-water pipes, and the only preventive is to soften the water (see Chapter XII).

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# CHAPTER IX

## CISTERNS

Where the intermittent system of supply is still in operation, the provision of cisterns is absolutely necessary; and even with the so-called "constant" system, cisterns are useful, as a constant supply cannot always be maintained, owing to defects or alterations in the main or communication pipes, or to a partial failure in the supply itself. Cisterns for the storage of water for domestic purposes have been made of various materials, including (1) slate, (2) stoneware, (3) lead-lined wood, &c., (4) cast iron, (5) wrought iron, and (6) steel.

**Slate** is clean but very heavy, and the joints are liable to leak. Owing to the weight and limited size of slate slabs obtainable, they cannot be made of great capacity. They are very suitable near the sea, or where the water contains nitrates. The joints ought to be put together with neat Portland cement, as red and white lead may contaminate the water.

**Stoneware or Glazed Fire-clay Cisterns** are also very heavy but clean, and can only be obtained of a limited capacity.

**Lead-lined Wooden Cisterns**, although at one time frequently used, are not to be recommended, owing to the danger of the water becoming contaminated by being in contact with the lead. As already mentioned, certain waters, notably rain, peaty, and other soft waters, dissolve the lead, which, even when the amount is infinitesimal, may produce symptoms of poisoning in persons who habitually drink the water. Hard water causes a scale to form on the surface, which protects the metal from further action. In cleaning a lead-lined cistern, the surfaces should be lightly scrubbed down so as not to remove this coating and so expose a fresh surface of lead.

Lead-lined cisterns should not be used near the sea, or where the water

contains nitrates. They may be used, however, to supply certain fittings such as baths and water closets, even where it may not be advisable to store water in them for cooking and drinking.

A wooden cistern of the required capacity is first made, and then lined with sheet-lead weighing from 5 to 7 lb. per square foot, as explained in Section III, pp. 159–162.

**Cast-iron Cisterns** are heavy, but can be built up of any capacity, by means of plates of various sizes, having flanges round the outer or inner edges through which they are bolted together (fig. 312 and Plate XV). The joints between the plates are caulked with a *rust-joint cement* or *swarf*, as it is termed, which may be either quick- or slow-setting, and composed by weight as follows:—

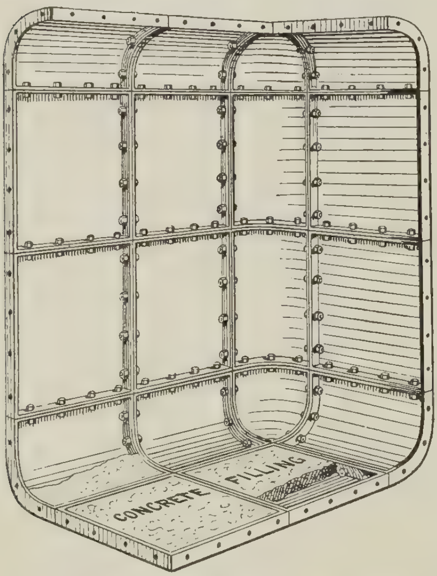



Fig. 312.—Section of Tank with Rounded Corners, showing concrete filling

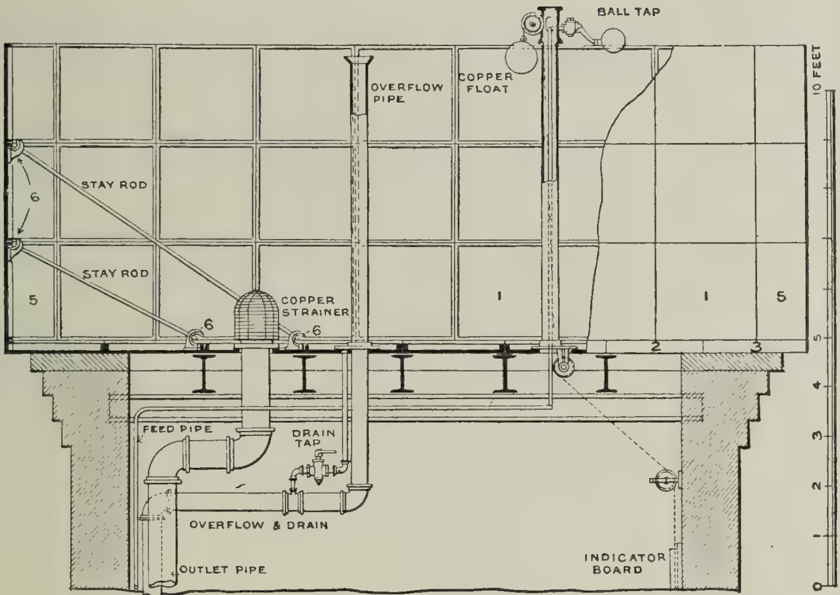
*Quick-setting*, 1 part sal-ammoniac (powdered), 2 parts flour of sulphur, 80 parts iron turnings, borings, or filings.

*Slow-setting* (and best), 9 parts sal-ammoniac, 1 part flour of sulphur, 200 parts iron borings as before.

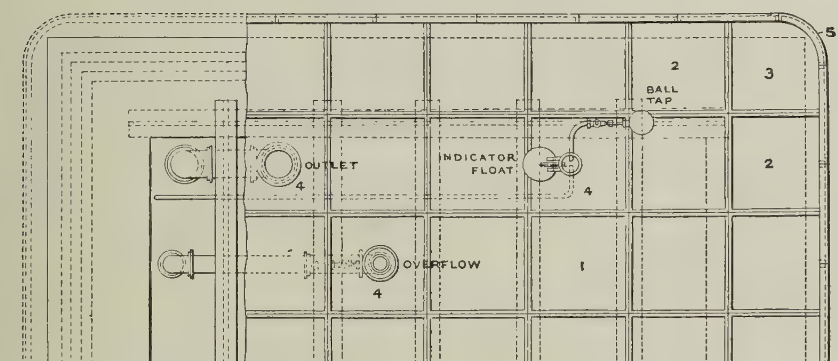
The plates may be square or rectangular in shape, and should not exceed 16 sq. ft. in area, or 4 ft. by 4 ft. each, and the thickness may vary from $\frac{1}{4}$ in. to 1 in. according to their position in the cistern. The bolts should be made water-tight with yarn and red lead. Horizontal and diagonal stays or ties are required in large tanks to assist the flat surfaces to resist the pressure of water against them.

Messrs. Mather and Platt have now standardized the manufacture of cast-iron tanks to enable them to be built from stock plates (Plate XV). These plates are cast in various sizes up to 2 ft. 6 in. square, with flanges either inside or outside, special bottom, corner, and curved plates being made to match (see details Nos. 2, 3, and 5), so that tanks of almost every shape and size can be constructed. The plates are machined true within $\frac{1}{1000}$ in. The flanges are machined true right across, and the bolt-holes drilled from the solid at 6-in. pitch. Outlet or inlet plates (No. 4) with holes in the centre $7\frac{1}{2}$ in. diameter are also provided, reducing flanges being used when smaller holes are required. Universal brackets (No. 6) for stay rods, suitable for attaching to tanks having either internal or external flanges, can also be obtained. All the plates are of the same thickness ($\frac{3}{8}$ in.), the proportion of flanges to plate area rendering it unnecessary to use thicker plates in the bottoms and lower tiers of plates in deep tanks.

A number of tanks 10 ft. in depth, built of these plates, have been found quite satisfactory. The cost of erection is small, a handy fitter being able

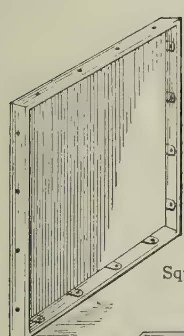



SECTION



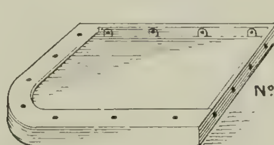

HALF PLAN

The Nos. refer to the Nos. of the Stock Plates



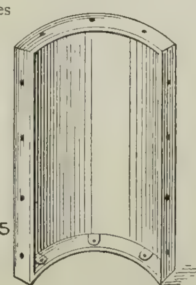
Nº 1

Square Plate



Nº 3

Bottom Corner Plate



Nº 5

Curved Corner Plate

Bracket

Nº 6

Nº 2

Bottom (outside) Plate

Nº 4

Bottom (inlet or outlet) Plate

MATHER & PLATT'S CAST-IRON STANDARD-PLATE TANKS

to work without any assistance except that of a labourer. The joints are made with ordinary red-lead putty.

Cast-iron cisterns are seldom fixed indoors, but are often used for the larger storage tanks outside, and may be rectangular (with or without rounded corners), circular, or polygonal in plan. They may be supported on rolled steel joists carried by walls or piers, cast-iron columns, or steel stanchions, the towers being of such a height as to enable all fittings or interior cisterns to be supplied by gravitation, and to command for fire-purposes all buildings in the vicinity. They should be periodically painted to preserve them from rust.

**Wrought-iron Cisterns** galvanized (fig. 313) are now in most general use, and can be manufactured in any shape or size. The ordinary sizes are formed out of ⅛-in. sheets riveted to angle irons with ⅜-in. rivets at 1½-in. pitch. They are comparatively light and easily handled, and are fairly durable. The zinc coating is, however, affected by certain soft waters, and by rainwater collected in smoky districts, with the result that the iron is liable to rust.

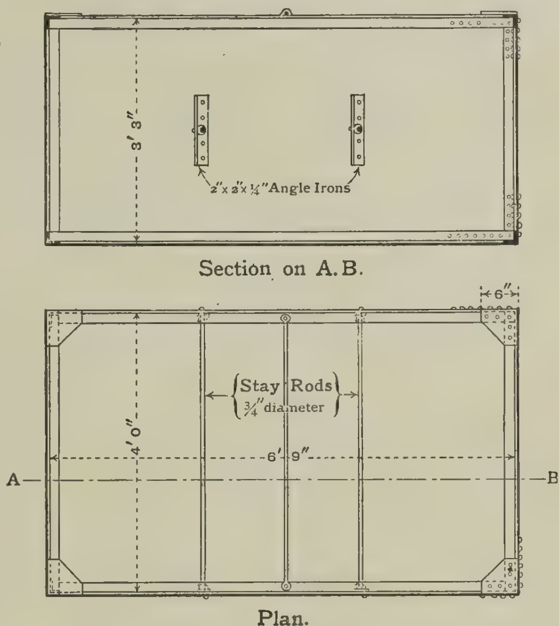


Fig. 313.—Wrought-iron Cistern to hold 500 gallons

**Steel** is now often used instead of cast iron for large storage tanks for external use. Such tanks are built up of plates and angles riveted together, and are often supported on steel framing as shown in Plate XVI, which illustrates a tank of this kind erected by Messrs. Duke & Ockenden.

Cylindrical tanks formed of steel boiler plates are now being made with spherical bottoms, which require support only round the edges, supporting girders and internal stays being unnecessary.

**Size of Cisterns.**—In calculating the size of a cistern required for any particular building, it is usual to provide for two days' consumption, and it is generally assumed that in an ordinary house the occupants use on an average from 20 to 30 gal. per head daily. Assuming an average of 12 persons, using, say, 25 gal. each per day, then the consumption to be provided for is $12 \times 25 \times 2 = 600$ gal.

A cistern of this size can easily be manufactured in galvanized wrought iron, and can be obtained in stock sizes or specially made of any particular shape. When made to special dimensions they are rather more expensive. In addition to the household requirements, provision

may have to be made for horses, carriage washing, garden watering, fire hydrants, &c.

It is often more convenient to have two or more small cisterns instead of a single large one, as the cistern room may be so constructed that a large cistern, if inserted during the erection of the building, cannot afterwards be removed without being broken up.

**Position and Protection of Cisterns.**—The cistern should be fixed at a sufficient height to supply all the fittings by gravitation; in a well-lighted and ventilated position, easy of access for inspection or cleaning; and fitted with a close-fitting lid or cover to keep out all dirt, dust, &c. If in an exposed situation, it should be cased in some material to protect it against frost—say, felt, silicate cotton, or other non-conducting material used with an outer casing of wood. If the cistern is large, a portion of the cover over the ball cock should be hinged, so as to admit of ready access for inspection or repairs.

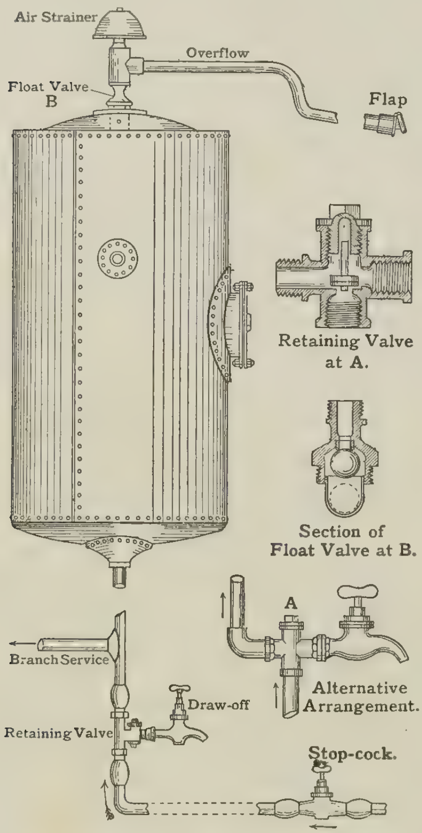


Fig. 314.—Harding's Patent "Simplex" Cistern

**Closed Cisterns.**—The Royal Commissioners appointed in 1895 reported very strongly on the inconvenience experienced by consumers in consequence of unavoidable temporary intermissions of the supply, and stated that there would be a distinct advantage in having properly designed means for storage of water in houses, but that on no account did they advocate a return to the old defective cisterns with movable wooden covers. What they considered was required, was a cistern so constructed as to exclude alike the possibility of the entrance of dirt from the atmosphere and the accumulation of deposit from the water itself, or practically an enlargement of the main.

Various patents have from time to time been taken out with the object of complying with these suggestions, and some of them have met with a considerable amount of success. They are all practically "enlargements of the main", some being intended to take the pressure of the mains, others being non-pressure.

**R. Harding & Son's "Simplex" Cistern** (fig. 314) consists of a strong high-pressure galvanized wrought-iron or steel cylinder, with self-cleansing bottom and closed top, to which no air can be admitted without passing through an air-strainer excluding all impurities. Only one pipe is required,

that from the main to the bottom of the cistern, and to this pipe the various branches and draw-offs are connected. A float or air valve takes the place of the ordinary ball cock. The floating ball of this air valve, which is fixed on the top of the cylinder, allows the air to escape when filling, and automatically rises against a non-corrosive seating and effectually closes when full, so that no water can escape. The air-strainer is packed with fibre and cotton wool round a perforated pipe, the bottom of the dome being also perforated. It thus acts as an inlet or outlet according as the water is falling or rising in the cylinder. The straining material should be renewed occasionally.

When full, the cylinder is under the full pressure of the main, and water is drawn direct from the main so long as the supply is constant, but should any interruption take place, the retaining valve, fixed at or below the lowest draw-off tap, automatically closes, and the supply is then drawn from the cylinder. When the main supply is resumed the cistern refills, and water is again drawn direct from the main.

To ensure circulation of water in the cylinder a flange can be fixed in the upper half, from which branches are taken to supply flushing or feed cisterns, which should preferably be fitted with the "Anti-back-draught ball valves" to prevent any risk of foul air being drawn back into the cylinder or empty pipes.

The cylinders can be provided with bolted-down tops, or with manholes at the sides, and in various sizes from 20 up to 200 gal. capacity, their heights being usually about twice their diameter. They are manufactured out of $\frac{1}{8}$-in. or $\frac{3}{16}$-in. plate, and tested to 25 lb. or 40 lb. pressure per square inch.

**R. Harding & Son's "Enclosed" Cisterns** (fig. 315) can be made to any size and shape, and are not subject to the pressure of the main. They are fitted with a special air-strainer and ball valve, which is accessible for repairs from the outside without removing the cover plates, and are made with self-cleansing bottoms sloping to the centre, and with raised oval manholes on the top for the reception of the ball and lever of the ball cocks, as they rise when the cistern is full. The air-strainer is fixed at the top to allow the air to escape when the cistern is filling, and to exclude all impurities in the air which enters when water is drawn off. Two service pipes are taken from the cistern, one from the bottom leading to the hot-water feed cistern, and the other, which stands about half-way up inside the cistern, supplying all the draw-off taps.

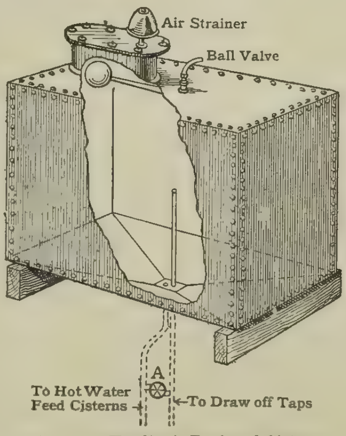


Fig. 315.—Harding's Enclosed Cistern

When the supply fails at the taps, it indicates that the supply has been suspended from the main and that the cistern is half empty. Water, however, will still be available for the hot-water system, and by opening

the connecting stop cock on the by-pass at A, water can also be drawn from the draw-off taps until the cistern is completely empty. When the water is again turned on at the main, the stop cock at A should be closed.

These cisterns are manufactured out of $\frac{1}{8}$-in. plate, either rectangular or cylindrical in shape, and in various sizes from 200 up to 1000 gal. capacity. Closed-top cisterns can also be obtained of less capacity and lighter gauge, with flange at the bottom for one service pipe only.

**Alexander's Patent Cisterns** (fig. 316) are so constructed as not to be under pressure, and therefore do not require to be of great strength, and can be made of any capacity and of a shape suitable for any position, at a cost very little in excess of an ordinary cistern. The bottom is made sloping towards the outlet, so that no accumulation of deposit can take place from the water itself, and, as the cistern is "enclosed", no dust or impurities of any sort can get access to it.

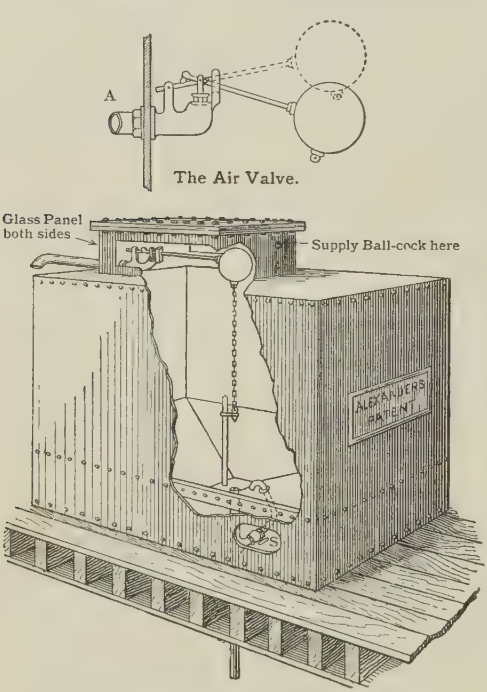


Fig. 316.—Alexander's Patent Cistern and Air Valve

Aeration is limited to the surface of the water stored in a small box fixed on the top of the cistern, and containing a patent air valve and ball cock, which form an essential feature of the system. The air box measures about 20 in. by 12 in. by 12 in., and with slight variations in the dimensions is suitable for a cistern of any size. It can be fitted with glass panels in the sides to allow the action of the air valve and ball cock to be seen.

**The Patent Air Valve** (A, fig. 316) is arranged to serve five purposes automatically:

1. It closes the air box against the outer atmosphere.
2. It admits air as water is being withdrawn.
3. On cessation of withdrawal, and on the water rising to the normal level, it allows air to flow out, and on resuming its seat it again closes the air box against the outer atmosphere.
4. In the event of the ball cock leaking, and water rising above the normal level, it is opened by a reverse action, and an open waste (or warning-pipe) carries away the surplus water.
5. Combined with another valve suspended from its float, it gives warning to the householder, when the service from the main is interrupted, by closing the mouth of the outlet pipe after a certain quantity of the stored water has been drawn off. Thus warned by the stoppage, the con-

sumer can open the stop valve S on the supplementary outlet, by which means the water stored in the cistern can be drawn upon through the same fittings, until the cistern is empty.

**Overflow and Waste Pipes.**—As already explained, all cisterns should be provided with overflow pipes, so fixed as to come into action before the water can run over the sides, in the event of the ball valve failing to shut off the supply at the proper time. They should be fixed not less than 2 in. clear below the top of the cistern, and should be large enough to take away the surplus water as quickly as the supply pipe can deliver it. As the supply pipe would be acting under pressure, the overflow must be larger, and it is sometimes made twice the diameter. An overflow fixed to a cistern on the ground floor of a building may require to be larger than those fixed to cisterns on the upper floors, if served from the same rising main, as the pressure would be greater at the lower level.

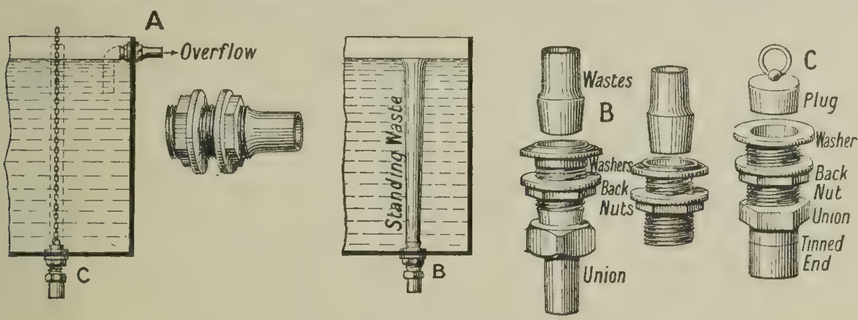



Fig. 317.—Fittings for Cisterns

All overflows should be tested by tying down the ball valve, so that the pipe can discharge full-bore under its normal pressure, when the overflow pipe should be sufficient to take the water away without its flowing over the sides of the cistern.

The overflow pipe may be connected to the side of the cistern by means of a brass union or boiler screw (A, fig. 317), which may have two nuts, as shown, or a fixed flange outside and a nut inside, the former being the better arrangement.

When the pipe is taken through the side near the top of the cistern, it can only act as an overflow, and as it is desirable that proper means should be provided for cleaning out the cistern, it is usual in that case to fix a washer and waste plug in the bottom, a chain being attached to the plug so that it can be opened from above (C). Instead of a chain a piece of pipe is sometimes used, having the plug at the lower end and closed at the top, as shown by dotted lines. Through this outlet the sediment, and the dirty water produced in cleaning the sides of the cistern, can be thoroughly flushed out, the fresh water being turned on through the ball valve to assist.

The **standing waste** (B, fig. 317) serves the purposes of an overflow and waste. The mouth is trumpet-shaped, the diameter at the top being usually twice that of the pipe itself. The lower end is slightly tapered and fits

accurately into a sunk washer or seating fixed in the bottom of the cistern. Two varieties are shown, one having a union for lead pipe and the other being screwed for iron pipe. When the standing waste is in position, the water can overflow into the top, and when it is lifted out, the whole of the water escapes through the fixed waste pipe below. Some water companies, however, object to the standing waste, as there is a possibility of leakage at the foot. Sometimes when the water freezes in the cistern, it raises the standing waste from its seating and allows the water to escape. To prevent this, the standing waste should be secured at the top.

**The point of discharge** of overflows and wastes should be in the open air in a conspicuous position, so that attention is at once drawn to the fact that something is wrong with the ball valve. On no consideration should they be connected direct to any soil, drain, or ventilating pipe, nor should they be made to discharge over any gully. As under normal conditions they would be empty, foul gases would readily pass through them

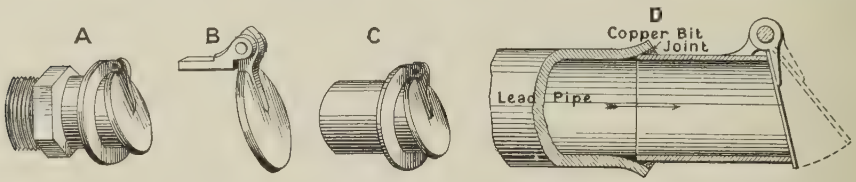



Fig. 318.—Flap Valves for Overflows

A, Screwed for iron; B, for soldering to lead pipe; C, for soldering to lead pipe, as shown at D.

and so contaminate the water in the cisterns. It is advisable to protect their mouths by galvanized iron or copper wires, to prevent birds or insects from having access to them, but it is a better plan to fix a hinged brass or copper flap on the outlet (figs. 318 and 319). This flap would ordinarily be closed, but it should be hung so as to open readily against the slightest pressure from the inside. The outlet end should be at least 1 ft. below the inlet, so that there would be sufficient head of water to open the flap during an overflow, and some water companies insist on the outlet end being below the level of the bottom of the cistern. This flap would not be required if the unfreezable overflow valve shown in fig. 311 were used, or if the inlet were trapped by being turned down as shown by dotted lines in fig. 317.

**Safes.**—Wherever cisterns are fixed over ceilings, or where damage is likely to arise from leakage or condensed moisture dripping from them, a tray, or "safe" as it is termed, should be placed underneath, to receive the water. This safe (fig. 319) is formed of wood, and lined with sheet lead weighing 5 or 6 lb. per square foot; a rim or curb should be formed round the outer edge from 2 in. to 6 in. high, and the lead dressed over it, the whole forming a sort of dish, projecting sufficiently far beyond the sides of the cistern to take all condensed moisture and water from leakage or other causes. The wood bottom should be laid to fall to the outlet, which may be in the centre or near one edge, and the hole for the waste pipe must be

rebated around, as otherwise the mouth of the waste pipe will stand up a little above the bottom of the safe.[1]

A waste pipe must be provided for the safe, of the same diameter as the overflow pipe from the cistern, and may be a separate pipe or connected with the overflow or with the outlet pipe from the standing waste, as shown by dotted lines (fig. 319). The junction of the two pipes can be formed underneath the safe. A simpler plan is to let the overflow pipe from the cistern discharge into the safe, the waste-pipe from the latter being fixed of ample size to carry off the water.

The cistern in the upper figures is shown supported by rolled iron or steel joists, which are sometimes necessary; but under ordinary circumstances, when the safe rests on strong wood joists, the cistern is blocked up a few inches by oak bearers cut somewhat as shown in the lower figure. Cubes of stone measuring about 6 inches on each side are sometimes used.

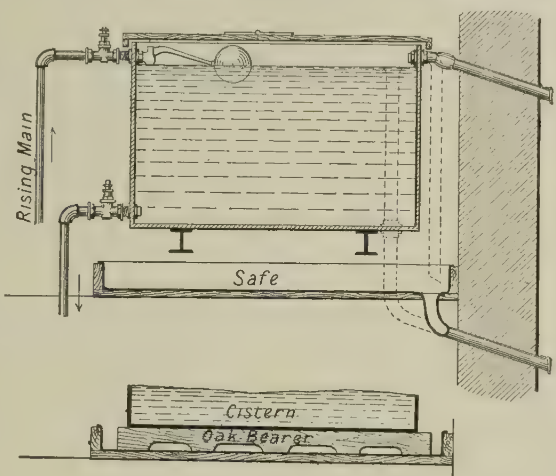


Fig. 319.—Safes under Cisterns

**Flushing Cisterns** or **Water-waste Preventers**, for water closets, &c., must be provided to cut off all direct communication between the drinking water and the water closets, &c., and thus avoid any risk of contamination. They must be fitted with ball cocks and overflow pipes, but will be more fully described in Section IX.

# CHAPTER X

## COCKS AND VALVES

Cocks or valves are required to regulate the flow of water through the pipes, or to discharge it at certain points, and are usually named according to the position they occupy or the purpose they serve. Thus there are stop cocks, ball cocks, and bib cocks or taps.

A **Stop Cock** or **Stop Valve** is a fitting which can be fixed at any point in a length of piping, to regulate the flow of water or to shut it off altogether if required.

A **Ball Cock** or **Ball Valve** automatically regulates the discharge of water into cisterns, by means of a lever arm and floating ball.

[1] For further details see pp. 165 and 166, Vol. I.

**Taps**, bib taps, bib cocks, bib valves, plug taps, tube cocks, draw-offs, cranes, and crans are some of the names given to fittings through which water can be drawn off.

**Cock.**—The terms *cock* and *valve* are often rather loosely applied. Generally speaking, a *cock* is understood to be an arrangement for controlling the flow of water through a pipe, or for discharging it from the pipe, by means of a conical metal plug having its axis at right angles to the direction of the pipe, and with a slot, port, or opening through it (fig. 320). The plug is turned on its axis by means of a fixed handle, or by a loose lever handle, and a quarter-turn is sufficient to open or close the port in the plug by turning it in the direction of the flow or at right angles to it.

A **Valve**, on the other hand, whilst practically serving the same purpose as a cock, has a loosely fitted valve or diaphragm, which is acted on by a screw spindle with handle or wheel (fig. 321). The act of screwing down

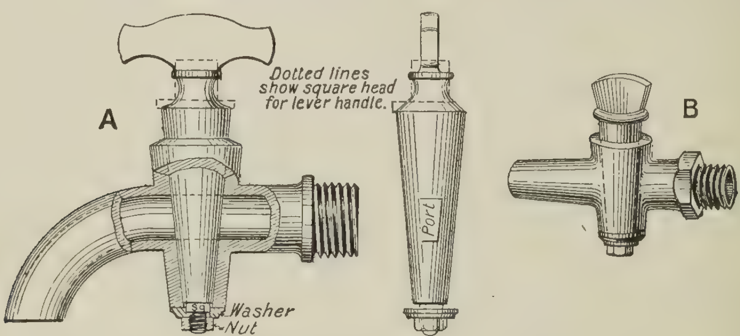



Fig. 320.—Ground Plug Cock or Tap

A, As tap screwed for iron pipe; B, as stop cock for lead and iron pipes.

the spindle presses the face of the valve against a special seating, and so closes the orifice. On unscrewing the spindle the pressure of the water forces the valve off its seat, and the water passes through.

**Disadvantages of Plug Cock.**—It will thus be seen that with a plug cock the water can be turned on or shut off almost instantaneously, and this is a serious defect when the cock is used for water supplied under pressure. When the stream of water flowing full-bore is suddenly arrested by the plug being turned, the check causes concussion in the pipe, which varies according to the pressure of the water. The vibration may work the hold-fasts loose, and may possibly eventually split an iron pipe, and cause a lead pipe to bulge and ultimately burst. With the screw-down pattern, the flow of water is gradually reduced without doing any harm.

Another objection to the plug cock is its liability to leak after being a short time in use, especially if the water is "gritty". As the plug gets worn it can be tightened up by means of a screw nut at the bottom, but to prevent leakage it frequently requires to be taken out and "reground". After unscrewing the bottom nut, the plug can easily be withdrawn from its seating in the body of the cock. This form of cock should be employed, if at all, only where the water is supplied at a low pressure, as on the service pipes from a house cistern, or the side boiler of a kitchen range.

To illustrate the amount of concussion to which pipes are subjected by the sudden closing of a plug tap, Mr. (now Sir) A. R. Binnie carried out a series of experiments, which clearly indicate the evil effects of the continuous hammering where the water is supplied under high pressure. He caused a plug tap having an effective water-way of 0·152 in. to be fixed at one end of a $\frac{3}{4}$-in. lead pipe, 114 ft. long, which was attached at its other end to a 3-in. main, with the following result:—

| | Lb. per square inch registered by Pressure Gauge when fixed close to | |
|---|---|---|
| | Tap. | Main. |
| Before opening ... ... | 125 | 125 |
| When opened ... ... | 20 | 120 |
| When shut quickly ... ... | 550[1] | 220 |

**Tube Cocks** for lavatories, &c., should be properly ground, and should have a water passage cut around the key, so that the rise and fall of the tube will not affect the flow of water.

**Screw-down Valves**, suitable either for stop or draw-off purposes, are a great improvement on the plug type. In fig. 321, two varieties are shown

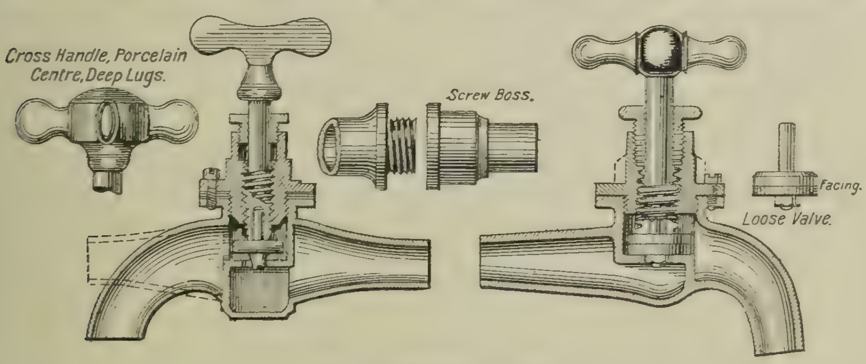



Fig. 321.—Screw-down Valves

with ends for connecting to lead pipes by means of wiped joints. Sometimes a screw boss is wiped to the lead pipe, and the end of the valve is finished with a shoulder and screw, as shown in the upper part of the illustration; with this arrangement the valve can easily be taken off and a new one fixed in its place. A similar screwed end is used for attaching a valve to an iron pipe. The dotted lines in the left-hand section show the fitting arranged as a stop valve.

These valves are usually made of brass or gun metal, and contain a loosely fitted valve, which is acted on by a screw spindle having a crutch or handle (lever or wheel) at the top, and working in a stuffing-box. If the loose valve were firmly fixed to the spindle, the constant friction

[1] After numerous vibrations, the pressure returned to 125 lb.

would soon wear away the facing (whether metal, leather, fibre, or other substance); but, as it is loose, the wearing action is very slight, hence the renewal of the facing is seldom required. In the cheap fittings the valve is quite loose, but in the best kinds it is loosely attached to the spindle by screws in a journal. If a leakage occurs when the spindle is screwed tightly down, it shows that the face of the valve requires renewal, and this can be carried out by turning off the water at the nearest stop cock and then unscrewing the top of the defective fitting, when the loose valve can be taken out, the old facing removed, and a new one fixed.

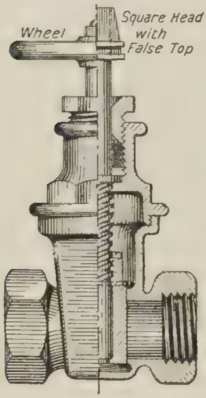



Fig. 322.—Straight-way Stop Valves

When the upper portion of the valve is screwed down into its proper position, a small set screw should be passed through the two meeting flanges to prevent the upper portion working loose, owing to the constant opening and shutting of the valve. Some cheap valves are not fitted with this set screw.

The orifices in valve seats of many screw-down valves are less in diameter than the pipes to which they are fixed, and when this is the case it is frequently specified that they should be of a larger size; for instance, a $\frac{3}{4}$-in. pipe might require a 1-in. stop cock.

**Full-way Stop Valves**, known also as straight-way, full-bore, or clear-way, are obtainable, however, worked on the same principle as sluice valves, which, when opened full, do not restrict the flow of water (fig. 322).

**Renewable Valve Facings.**—There are certain forms of tap in the market which enable the valve facings to be renewed without having to shut off the water during the operation. One of these is Guest & Chrimes's Double-acting Loose Valve (fig. 323), in which there are two loose valves, one above the seating, as in the ordinary pattern, and the other working from below. When the facing of the upper valve, which does most of the work, requires renewal, the top of the valve is unscrewed and the loose valve removed as before. The pressure of the water, acting on the lower side of the bottom valve, presses it against the lower seating, closing the orifice and preventing the escape of any water. In some fittings this bottom valve is acted on by a spring, and in either case, if the bottom valve gets out of order, the water must be shut off before the defect can be remedied. As will be seen from the section, the bottom portion of the valve can be unscrewed as well as the top.

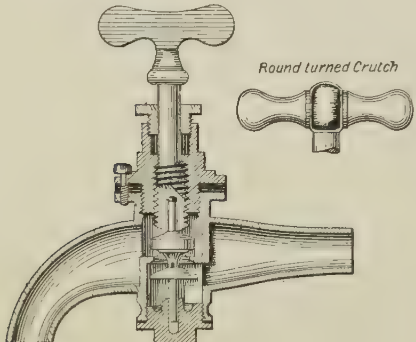



Fig. 323.—Double-acting Loose Valve

Stone's "Constant Supply" Double-valve Screw-down Stop Cocks (fig. 324) are also provided with two valves, but both actuated by the

same screw-spindle. Double security against leakage is thus ensured, and when closed the upper portion can be removed and the stuffing-box re-packed under pressure, the lower valve being kept closed by the pressure of the water behind it.

Ham's Patent "Repairable" Bib Cock (fig. 325) is another form of tap which admits of having its loose valve renewed without having to turn off the water. It is a loose-valve high-pressure tap, and is furnished with an extra long shank, having a blank end, and with ports or slots in the shank, as shown at A, to allow the water to pass. When the tap requires repair, it has simply to be unscrewed a few turns, until the slots come opposite the solid portion of the ferrule, which thus shuts off the water by closing the water-way between the pipe and tap. The top of the tap can then be unscrewed and the necessary repairs carried out without having to shut off the main supply. This tap, like most others, can be supplied with screw ferrules, either for lead or iron pipes, as shown.

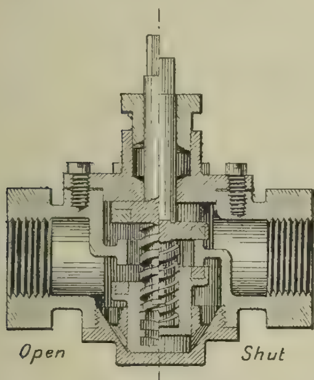



Fig. 324.—Stone's "Constant Supply" Double-valve Screw-down Stop Cock

**Lord Kelvin's Tap** (fig. 326).—In the ordinary forms of screw-down valve the leather or other facings of the loose valves require frequent renewal. This defect has been partly remedied in Lord Kelvin's valve, in which no

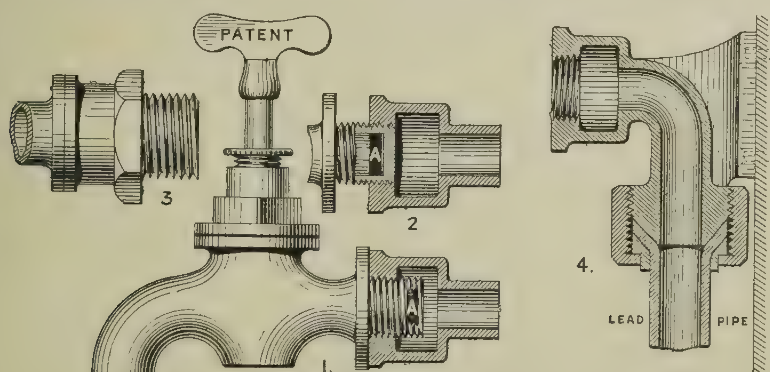



Fig. 325.—Ham's Patent Repairable Bib Cock

1, Usual position (port open); 2, Under repair (port closed); 3, Boss screwed for iron pipe; 4, Kneed boss and wall bracket with cone union joint to lead pipe.

perishable materials are employed, the seatings being entirely metallic. A (fig. 326) is the loose metallic valve, and B the seating, on which it is gradually pressed by the action of the non-corrosive spring C, on the shoulders of the rounded base of the stop D. E is an annular groove, the leakage from which escapes through the tube F.

The loose valve is thus rubbed upon its seat at every opening and

closing of the valve, and the meeting surfaces are uniformly worn. The spring prevents the valve being forced down unduly, whereas in ordinary fittings the screw is often turned with such force that the faces of the valve and seat are scored with any hard substance that may have lodged between them. Lord Kelvin's taps are made of the best gun metal, and tested to 400 lb. per square inch. They continue in good condition for a long time, but special tools are required for reseating them. They are supplied in various forms for draw-offs, and also as stop valves.

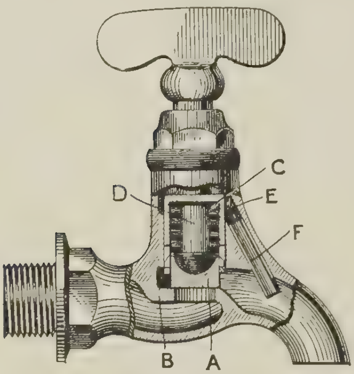



Fig. 326.—Lord Kelvin's Tap

**Press, Spring**, or **Push Taps** are occasionally used with the idea of preventing waste of water, as water will flow only whilst pressure is maintained on the spring. Where there is a high-pressure supply they are open to the same objection as the plug tap, as regards the sudden check causing "hammering" or concussion in the pipes. They are also expensive and difficult to repair, and when out of order may cause a considerable waste of water; consequently they are not recommended for general use. The Glenfield Company's "Non-concussive Self-closing Tap" (fig. 327) is simple in construction and easily opened, and has a full water-way; it is said to be absolutely non-concussive. When the button is pressed a small centre valve (between the lower end of the spindle and the top of the spring) is opened first, then the main valve opens, and the tap discharges full-bore. The spring carries the weight of the spindle and over-

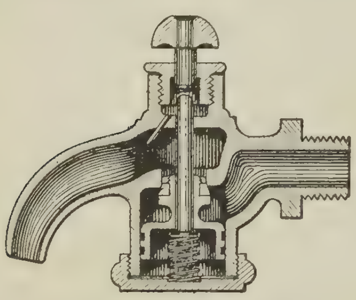


Fig. 327.—Patent Non-concussive Self-closing Tap

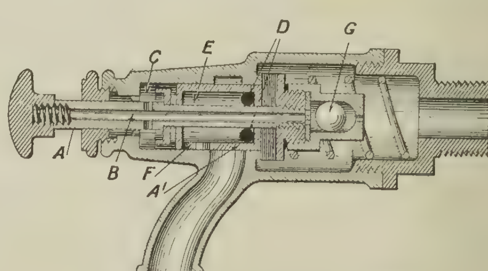



Fig. 328.—Self-closing Silent Non-concussive Valves

comes friction. It can be renewed or repaired by unscrewing the bottom, but the water must be shut off at the nearest stop cock.

**Self-closing "Silent" Non-concussive Valves.**—To obviate the sudden check of the flow of water under high pressure in supply pipes, Messrs. J. Stone & Co. have patented their Self-closing "Silent" Non-concussive Valve (fig. 328). This valve shuts the water off gradually, and so is really non-concussive. When the knob, which is connected by means of the spindle A to the sliding barrel $A^1$, is pushed forward, water is free to

enter both through the hollow chamber B into the water-cushion chamber C, and also through the circular apertures D into the chamber E, and thence discharges through the port F to the outlet. On releasing the spindle, the pressure of the inlet water, in conjunction with the different area of the outer and inner valves and the spiral spring at the back of the valve, causes an increase of pressure in the water-cushion chamber C, and also in the hollow chamber B. This action causes the back-pressure valve G to fall on a seating not perfectly water tight, but which allows the water from the cushion chamber to escape slowly, and during the return of the spindle to its normal position the port F *gradually* cuts off the inlet supply, thus effectually preventing concussion in the pipes.

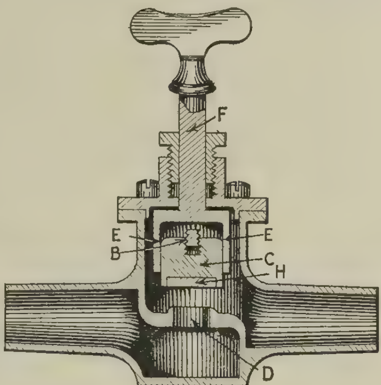
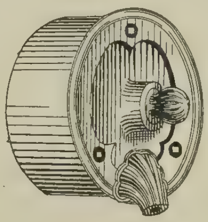


Fig. 329.—The "Waste Not" Screw-down Quick-turn Valve

**Waste-preventing Taps.**—To obviate waste of water owing to taps being left running, and the concussion caused by plug or spring taps being suddenly shut off, various devices have been introduced, by which only a limited quantity of water can be drawn each time the tap is opened.

The "Waste Not" Screw-down Quick-turn Valve (fig. 329), patented by Messrs. Tylor & Sons, has been found very efficient in this respect, and is in conformity with the Metropolitan Water Acts and with the regulations of many water companies. It is so arranged that, whilst the smallest quantity of water can be drawn, it cannot run continually, and, if left open, will close of itself after having discharged a few gallons, as may be arranged.



The plunger or falling plug C is fitted with a washer valve H, and moves up and down in a metal actuating cup or socket E E, which forms a carrier, and is raised or depressed by the handle F. When the handle is turned to open the tap, the cup rises, bringing with it, by suction, the plunger C, and so opening the passage for water. When the handle is screwed down, it depresses the cup E E, which takes down with it the plunger C on to the seating D. If the handle is not screwed down, thus allowing the water to run to waste through the tap, the plunger C, after being held up a short time by suction, falls on the seating D partly by its weight, but principally by the pressure of water, and is sound under any pressure

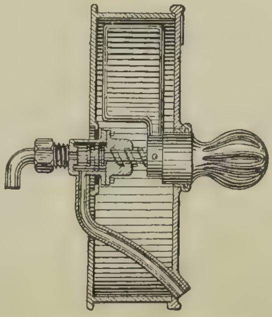


Fig. 330.—Ham, Baker, & Co.'s Wall Fountain

The draw-off taps to stand pipes, or those fixed to wells in courts for public use, should also be of a waste-preventing or self-closing pattern, to prevent waste of water in case they are left running. Fig. 330 shows a wall

fountain which will allow water to flow only whilst the weight is held up as shown. When the handle is released, the weight falls and closes the valve.

**Range or Boiler Cocks** (fig. 331).—Whether the water supply to a house is on the constant or on the intermittent system, any side boiler which is provided in the kitchen range must be fed through a small cistern fixed close at hand on the same level as the boiler. The feed cistern itself is supplied through a ball valve, either from the main or the storage cistern, and a pipe connection is made between it and the boiler, so that, as the hot water is drawn off, its place is taken by cold.

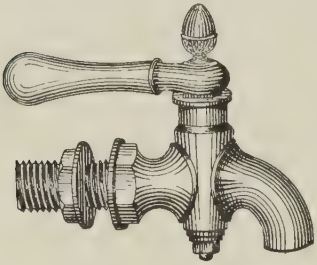
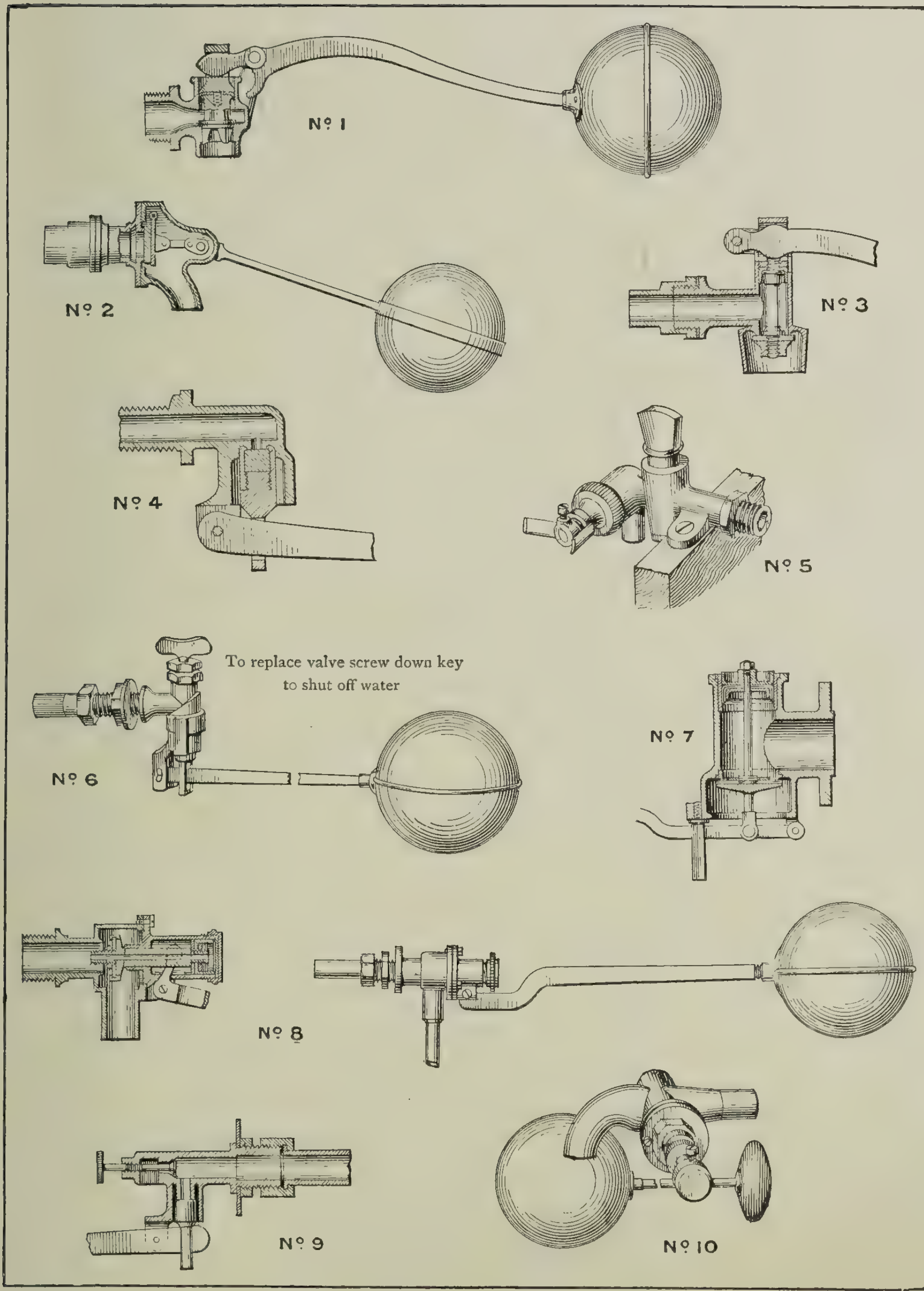


Fig. 331.—Range or Boiler Cock

This is sometimes termed the low-pressure system of hot-water supply, and it is usual for the hot-water tap, range cock or boiler cock (as it is variously named) to be of the plug-tap pattern. It is provided with a long screw which passes through the front of the boiler, and is secured in position by means of a back nut screwed up from the inside.

**Directions for Fixing Cocks, &c.**—All patent cocks and valves, before being fixed in position, should be carefully examined, and if they are to be fixed with solder to lead pipes, it is a wise precaution to take them to pieces before soldering, and to remove the valve and stuffing-box until the soldered joints have been made; otherwise the washers may become hard and useless and the grease in the stuffing-box be destroyed, so as to necessitate repacking. Care should be taken to see that the set screw, which secures the flange of the screw gland to that on the body of the cock (whether stop or bib) is properly tightened up to the washer which separates them; otherwise, with constant opening and shutting, the top may become loose and be unscrewed altogether, especially if the spindle works stiffly. This is more liable to occur in the case of stop-cocks fixed in pits underground, when they are opened by means of T keys, which exert a powerful leverage. A careless turn-cock, when opening these valves, may go on turning the handle after the valve is fully open, until he starts the screw gland, when a few turns allow the water to spurt out, unless there is a double-action valve. Even when the flanges are screwed together, the whole top of a stop-cock may be wrenched off through too great a force being applied to the key by jerks, when the spindle works stiffly.

**Ball Cocks or Valves.**—Ball cocks, ball valves, or ball taps are used for the purpose of automatically regulating the supply of water to cisterns or large tanks, and maintaining it at a certain level. There are many patterns in the market, a few of which are shown in Plate XVII. They should be made of hard brass or gun metal, tested to stand a certain pressure when half immersed, and should be periodically examined to ascertain that they are in proper working order, and the facings should be renewed when required. They are liable to stick, either when open or shut, but a slight movement of the ball by hand may be sufficient to free the valve.




## BALL VALVES

No. 1. Kennedy's "Equilibrium".
No. 2. J. Tylor & Sons' "Full-Way" (under 1-inch for low pressure).
No. 3. J. Stone & Co.'s "Equilibrium".
No. 4. J. Stone & Co.'s "Simplex".
No. 5. Kennedy's Combined Ball Valve and Stop Cock.
No. 6. J. Tylor & Sons' "Croydon" with Regulating Key.
No. 7. J. Stone & Co.'s "Equilibrium".
No. 8. Ham, Baker, & Co.'s "High Pressure".
No. 9. Ham, Baker, & Co.'s "Improved".
No. 10. Balanced Ball Valve.

The valve, whether opening vertically or horizontally, is acted on by means of a straight or bent rod or lever, having a hollow copper ball at the extreme end, which floats on the water. As the water level sinks in the cistern, the ball drops with it, and the other end of the lever opens the valve and allows the water to flow in, and as the water level is gradually raised, taking with it the ball, the valve is again closed. The size of the ball and the length of the rod are regulated by the diameter of the supply pipe and the pressure at which the water is delivered; the longer the arm the greater is the leverage exerted. The end of the lever should be screwed into a boss (see Plate XVII) on the ball instead of being brazed on, as is sometimes the case. No. 9 shows a ball valve suitable for supplying water to an automatic flushing tank. By means of the small screw valve at the end the rate of flow can be regulated to fill the tank slowly or quickly as desired. The discharge from the tank when full is ensured by the float valve opening a full-way passage as soon as it comes into action. In No. 10 the leverage can be altered by moving the ball rod and clamping it in position by the small set screw.

The valves may have metal facings or be furnished with washers or cup leathers. The washers are usually of leather, vulcanized india-rubber, or of india-rubber and canvas (termed insertion) in layers. The last-named wears best, and, being pliable, does not crack and tear. The cup leathers should be well soaked in oil, so as to be stamped into shape without cracking, and work smoothly when in action.

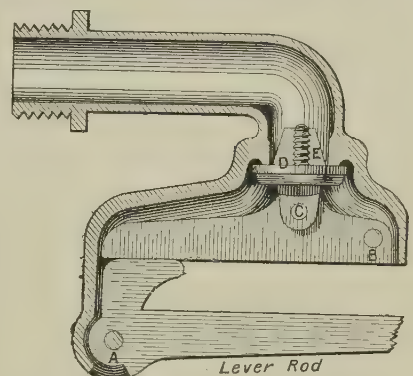


Fig. 332.—Tylor's Patent "Lever" Ball Valve

**Tylor's Patent "Lever" Ball Valve** (fig. 332) is simple in construction, of great strength, and capable of working with ease under a 450-ft. head of water, and of withstanding, without opening, any concussion to which it may be subjected, whether from pumping or other causes. It has a double or compound lever. The ball rod, which is pivoted at A to an extension of the valve box, has a projecting arm, which works against the free end of another arm pivoted at B, and to which the valve D is attached by the pin C. When the valve washer at D requires renewal, it can easily be got at by removing the cotter pins A, B, and C, and unscrewing the nut E. The valve can be obtained with screw ferrule for lead pipe, or screwed for iron pipe without ferrule as shown.

It is claimed for this valve that, as the rod is not attached to the working parts, it is not liable to be held up, and further, that the lashing of the water in the cistern by the ball, caused by the agitation of the water rushing into the cistern, is prevented. Many ball valves are open to this latter objection, and are responsible for the consequent waste of water.

**Testing Cocks and Valves.**—As the high-pressure constant system of water supply is now so general, it is absolutely necessary, if waste is to

be prevented, that fittings of the best quality and workmanship should be used. Hence most water companies insist on testing all fittings, and only those found satisfactory and stamped by their authority are allowed to be fixed. They usually keep samples of approved fittings for reference, but are always prepared to examine and sanction, if satisfactory, any other fitting submitted. Makers' names should be stamped on.

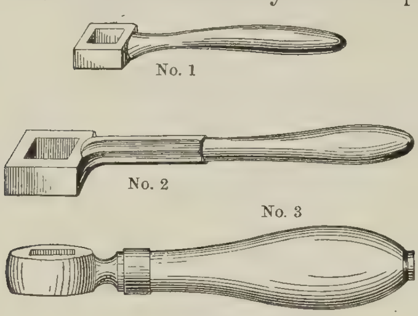


Fig. 333.—Lever Handles

**Lever Handles** (fig. 333).—In many cases it is advisable to have loose lever or spanner handles for stop or bib cocks, so that these cannot be tampered with by unauthorized persons. The screw spindle of the valve is finished with a short square projection, on which the square hole of the lever handle is placed when it is required to turn the water on or off. These lever handles may be of iron (galvanized or japanned) or brass (Nos. 1 and 2), and it is usual to have part of the handle of ebony (No. 3) where hot water has to be drawn, as metal levers get uncomfortably warm.

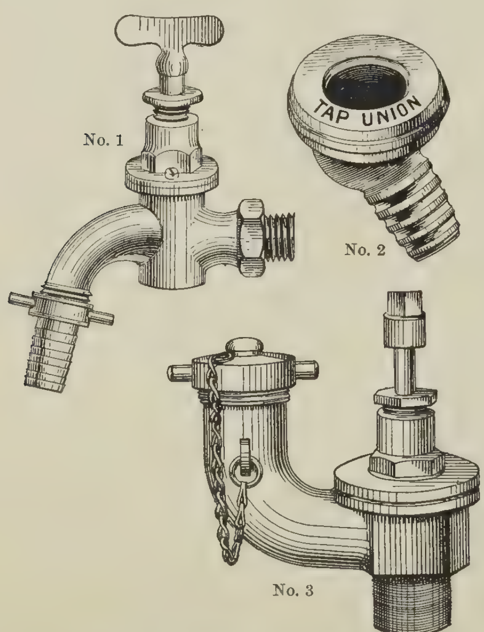


Fig. 334.—No. 1, Bib Tap with Screwed End for Hose Coupling; No. 2, Royle's Patent Tap Union with Hose-fixing; No. 3, Underground Garden Hydrant

**Water Supplies to Gardens.**—The water required for small gardens may be drawn from the scullery-sink tap or from a tap in the yard, into pails or other receptacles; or, by attaching a hose-pipe to the nozzle of one of these taps, it can be discharged at a distance limited only by the length of the hose and the pressure available.

No. 1 (fig. 334) shows a bib tap with screwed end for attaching to an iron pipe, and having a screw thread on the nozzle, on which a half-coupling for a hose-pipe is screwed, or Royle's patent tap union (No. 2) can be fitted on to the outlet of an ordinary tap. For larger gardens, special garden hydrants (No. 3) are fixed in pits underground, so that they are out of sight and not affected by ordinary frosts (see Plate XVI).

A special branch or hand pipe of copper or gun metal (A, fig. 335) can be attached to the extreme end of the hose by means of a hose-coupling D, or swivel-union hose screw, and a strong jet of water can be obtained by

screwing on to the hand pipe a gun-metal jet B (either with or without a cock); or various forms of nozzle can be used for spreading or distributing the water (C). These hand pipes are often fitted with spring valves which close automatically when the pressure of the thumb or hand is released; waste of water is thus prevented.

**Hose Pipe** may be of canvas, leather, or india-rubber, the last being sometimes strengthened by steel wire embedded in it in the form of a spiral spring, or "armoured" by an external spiral coil, which protects the tubing and prevents it from "kinking" or buckling. The armouring is varied according to the pressure which the pipe is designed to withstand. Each separate length can be fitted with a special half-coupling (D),

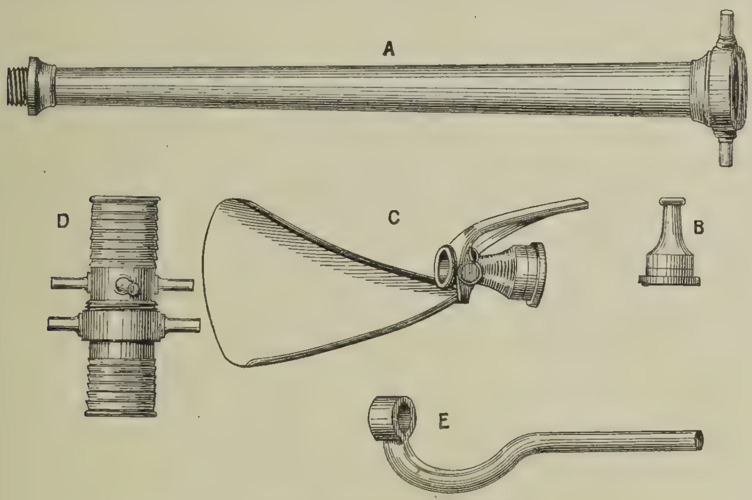



Fig. 335.—Distributing Apparatus

A, Hand pipe; B, Nozzle; C, Spreader; D, Hose coupling; E Wrench.

so that the various lengths can be jointed up quickly, similar to the lengths of hose for fire-brigade purposes. When not in use, the hose should be coiled up in such a way as to prevent kinking and splitting. Special hose-reels are made for this purpose, and when these are furnished with wheels, it is an easy matter to move them about, the hose being uncoiled from the drum as it is moved along.

**Pits for Valves, &c.**—All valves, meters, and hydrants, fixed underground, should be enclosed in a pit or shaft of a size sufficient to expose the whole of the fitting, including the joints connecting it to the pipe on the inlet and outlet sides. The pit should be protected on the surface by an iron frame, with a movable or hinged cover, so placed that when open the fitting will be exposed to view, and the opening should be large enough not only to admit the turn-cock's key to open or shut the valve, but also a man's hand and arm, so that, if the depth is not too great, certain repairs can be carried out without removing the frame or breaking into the pit itself.

The sides of stop-cock pits are usually of brickwork built in cement, and

may be 4½ in., 9 in., or 14 in. thick, according to their depth and the position they occupy. A pit 9 in. square in the clear, with half-brick walls, is sufficient for all ordinary stop cocks, and the upper courses of brickwork can be corbelled or gathered over to form a seating for the flanged frame of the iron cover. The bottom of the pit may be formed of a slab of stone, or of concrete from 4 in. to 6 in. thick, and projecting a few inches beyond the brickwork.

In the case of pits for stop cocks, sluice valves, and hydrants fixed in roadways, the sides and bottom should be strong enough to resist crushing by heavy traffic, and should be rendered in cement where water is likely

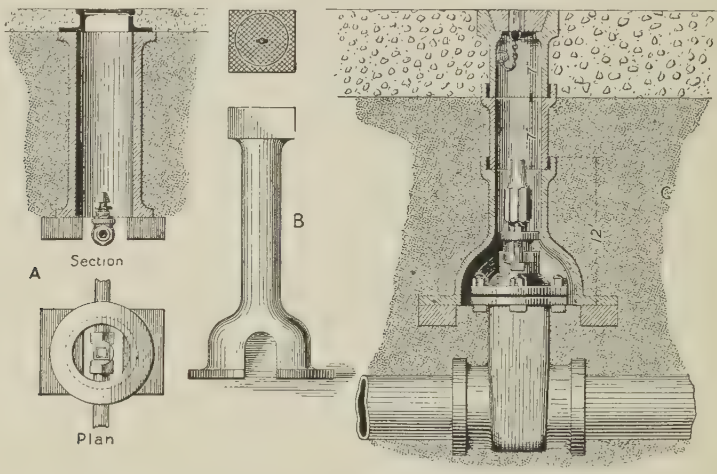



Fig. 336.—Pit Pipes

A, Stoneware with cast-iron cover; B, Cast iron; C, Cast iron with extension pipes.

to percolate into them from water-logged ground. With a porous subsoil, a small hole may be left at the bottom to drain away any waste water due to leakage, or to the action of the weep tap or anti-frost arrangement for emptying the dead water in the pipe beyond the fitting. If the subsoil is of a retentive nature, it may be necessary to excavate a small pit at a lower level and fill it with brick rubbish.

Sometimes the covers are surrounded with fine concrete for a width of from 6 in. to 9 in. outside the iron frame, and from 3 in. to 6 in. in thickness. The concrete should be well worked round the flanges of the cover, the top of which should be slightly above the surrounding ground, and the concrete surface should slope away from it, so that water may not drain into the pit through the key-hole or joints of the cover. If the stop-cock pit is in a paved surface, the paving should be continued up to the cover. In a gravelled or macadamized roadway the covers may be surrounded with a few rows of pitcher paving.

A 6-in. or 9-in. stoneware pipe is sometimes placed over an underground stop cock, care being taken that the edges are properly supported so that the weight may not rest on the pipe. Special stop-cock pit

pipes are supplied by Messrs. Ham, Baker, & Co. They are made of stoneware, in various lengths, from 15 in. to 30 in., and 6 in. in diameter, with flanges at the top and bottom (A, fig. 336). The top is protected by the special cast-iron cover. This is much cheaper than an ordinary brick-built pit, and admits of easy removal when the stop cock requires renewal or repairs, necessitating breaking into the pit. Deep surface boxes are also made in cast iron, either as a single casting (B) or in sections

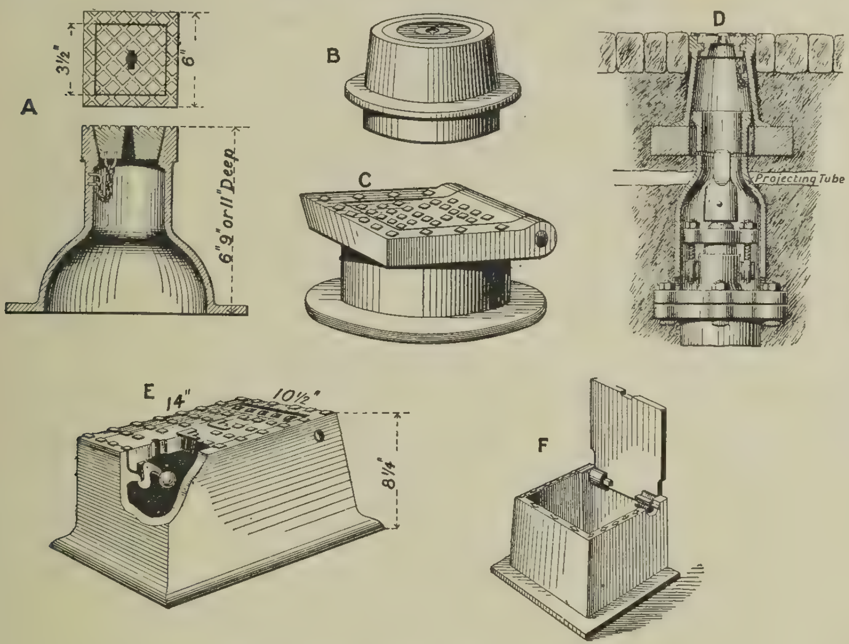



Fig. 337.—Surface Boxes for Stop and Sluice Valves

A, Square cover with chain; B, Circular cover; C, Hinged cover; D, Box for sluice valve; E, Box for fire hydrant with locking cover; F, The "Newport".

as extension pieces. C shows the application of these sections in forming a pit for a sluice valve, and fig. 341 how they may be used to form a combined chamber for sluice valve and hydrant.

The **surface boxes or tobies** (fig. 337) are generally made of cast-iron, but where they are exposed to heavy-wheeled traffic they must either be made "extra strong", to prevent risk of fracture, or the hinged portion must be made of malleable iron. They can be obtained either square (A), circular (B), or oblong (E) in plan, shallow or deep, suitable for footpaths or roadways, and with covers either loose, hinged, or attached to chains. In the latter case, whilst the covers cannot be removed, they can lie flat on the ground when open, instead of projecting upwards and forming an obstruction.

The "Newport" stop-cock box is fitted with a removable cover, which, in case of breakage, can be renewed without having to take up the frame, which is an advantage when the latter is fixed in a paved surface. The

hinge pins are partly square and partly round, and are readily withdrawn, as shown at F.

Letters are sometimes cast on the covers to indicate the nature of the fitting below, such as "S. C." for a stop-cock and "G. H." for a garden hydrant; if there are more than one of each kind, numerals may be added.

To prevent any unauthorized person tampering with the valves, covers are made with a locking arrangement (as at E, fig. 337), but this necessitates the turn-cock carrying a second set of tools, the absence of which at a critical moment may be a disadvantage.

**Valve Keys.**—Most of the underground stop cocks and valves have the tops of the projecting spindles formed square, so that they can be operated from the surface by the turn-cock's keys. As each size of valve has a particular size of spindle, the turn-cock must carry a number of keys with him when he goes his rounds, and this involves a good deal of labour, especially where there are a number of buildings each supplied with a separate water service, and from which it may be desired to shut off the supply at night during frosty weather, turning it on again in the morning. To remove this objection, adjustable caps are sometimes used (fig. 338), the square heads of which are of the same size, so that they can all be acted on by one key; the sockets of the caps are made to fit the various spindles, and to prevent their ready removal a small set screw is inserted at the side. Arrows on a brass disc indicate which direction to turn to "open" or "shut" the valve. Unless the turn-cock is careful, the heads of the smaller valves may be wrenched off by the force applied by him to the lever arms of the long T-headed key.

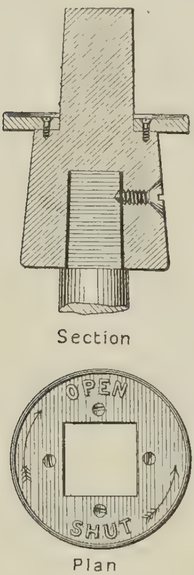



Fig. 338.—Adjustable Cap and Brass Indicator Plates for Spindle Heads

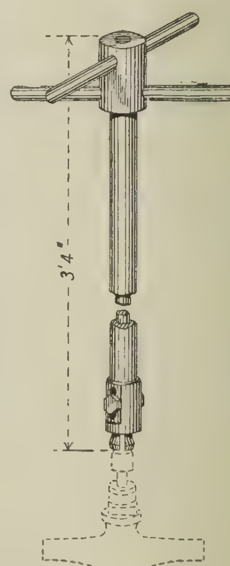



Fig. 339.—Sainty's Patent Key or Wrench

**Sainty's Patent Key or Wrench** (fig. 339) will open any ordinary stop cock fitted with either a crutch key or square head, or will grip the spindle if the head is broken off. The No. 2 size will also remove the screw gland of the cock for repacking, &c., without opening the ground.

# CHAPTER XI

## FIRE HYDRANTS AND MAINS

**Hydrants** or **Fire Cocks** are required for extinguishing fires, and are made in various patterns for external or internal use. Those fixed externally

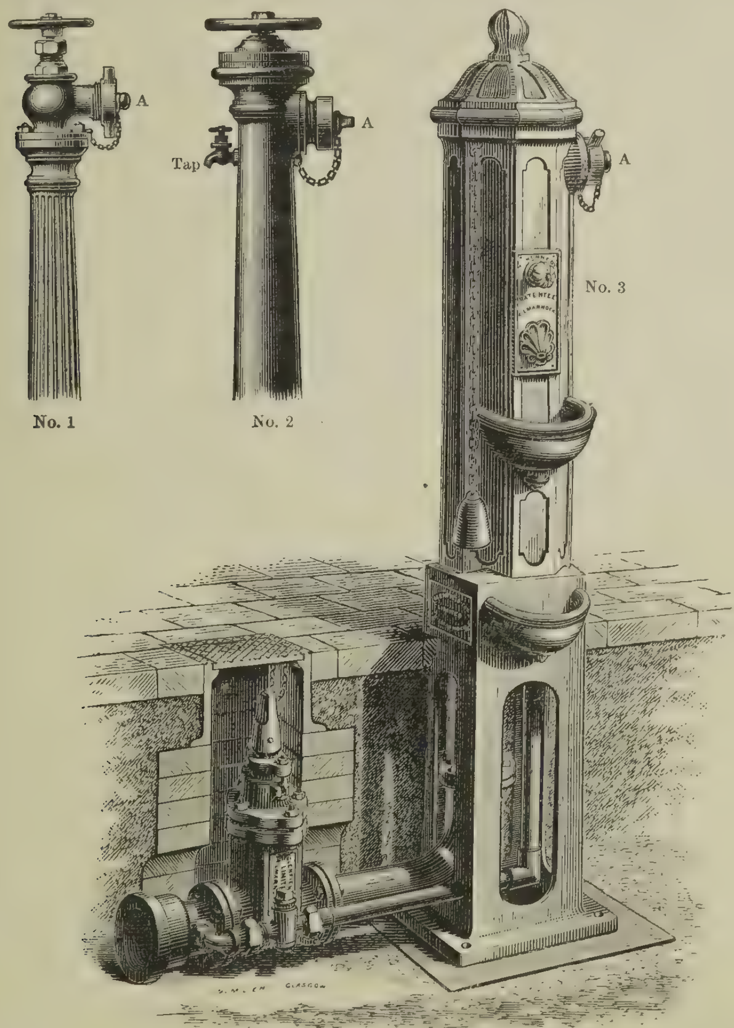



Fig. 340.—Pillar Hydrants

No. 1, globular; No. 2, with draw-off; No. 3, with by-pass to fountain.

may be classed as (1) pillar hydrants or stand posts, and (2) pit or sunk hydrants.

**Pillar hydrants** (fig. 340) are the most convenient, when they do not interfere with the traffic. They are easily seen, and by unscrewing the

cap A, which protects the outlet, the hose can be quickly attached. They can also be used as stand posts for street-watering or cart-filling, or as fountains, taps being attached for draw-off purposes, as shown in No. 2. The taps may be supplied from a pipe connected to the main beyond the sluice valve (which regulates the supply to the hydrant), and provided with a stop cock, to which access is obtained by opening the cover of the sluice-valve surface box, as shown in No. 3.

**Pit or sunk hydrants** (figs. 309, 310, 341) are enclosed in pits underground, and protected by movable iron covers suitably marked. Hence they offer no obstruction to the traffic, but as it may be difficult to locate them at night, or when covered with snow, &c., their position should be indicated by painted or enamelled metal plates fixed on the nearest wall.

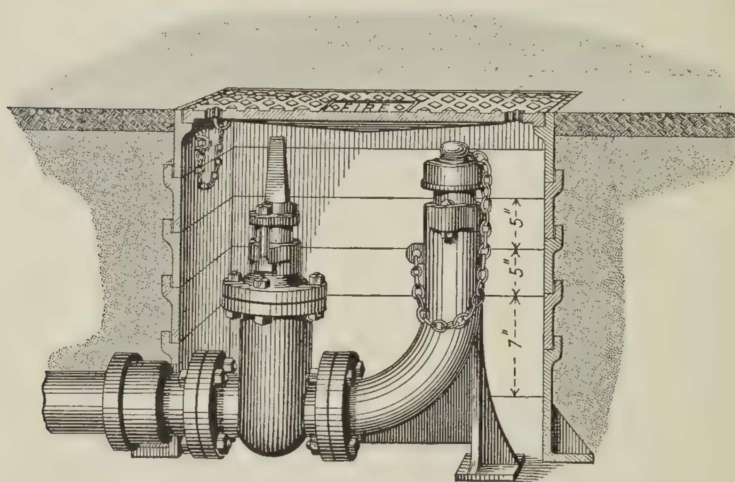



Fig. 341.—Pit or Sunk Hydrant with Single Outlet, Sluice Valve, and Cast-iron Extension Surface Box

Hydrants with one, two, or more outlets may be provided as considered necessary. A single outlet to a pit hydrant is fixed vertically (fig. 341), and requires a portable stand pipe to form the connection with the fire hose. With two outlets (fig. 342) the hose can usually be connected direct, as they are inclined outwards from the vertical.

**Hydrants and Valves.**—The water is turned on to hydrants by means of a loose key or a fixed hand wheel, which either opens a loose valve or a sluice valve, or depresses a ball; hence they are sometimes designated "screw-down", "sluice-valve", or "ball" hydrants.

Fig. 342 shows a double-outlet valve hydrant, having a cast-iron body, gun-metal spindle, valve, and valve seating, 4-in. inlet and 3-in. outlets, screwed to Brigade gauge. A section of an ordinary ground-plug fire cock is shown in fig. 343, and that of a ball-valve hydrant in fig. 344. The "Metropolitan" hydrant, which is fitted with Baker's Patent Frost Valve, is shown in fig. 310.

Ball hydrants are not recommended for pressures under 30 ft. head, or where the supply is likely to be intermittent. When the mains are empty

the ball drops, and foul air may enter unless a special screw-down valve has been provided (A, fig. 348). This valve not only prevents the access of air when the water is turned off, but prevents leakage in case of a defective ball. Ball hydrants may be useful at times, however, as air valves, during the time the mains are being charged, or as air escapes, the cap B having an air vent for the purpose. They are cheaper than the sluice-valve hydrants,

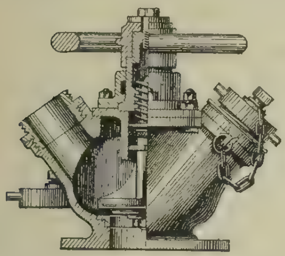


Fig. 342.—Hydrant with Double Outlet

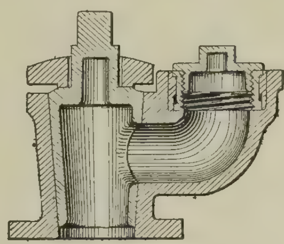


Fig. 343.—Ground-plug Fire Cock

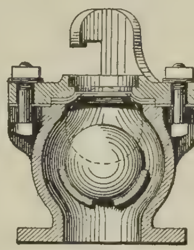


Fig. 344.—Ball-valve Hydrant

and can easily be kept in good order, as the working parts are attached to a portable stand pipe. The working parts of the sluice valves, being underground, are more liable to be injured or clogged with dirt, and, if the water is gritty, the gun-metal faces of the valves are apt to wear sufficiently to cause leakage.

**Connections.**—The sluice valves and hydrants are connected by flanges bolted together, the joint between the valve and main being formed by a

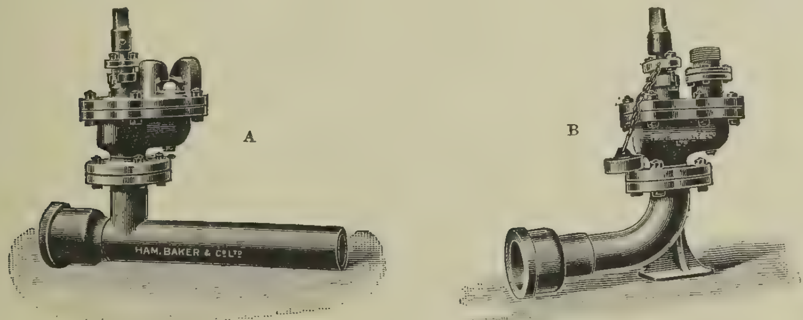


Fig. 345.—Flanged Joints of Spindle Hydrants

special casting having a flange at the end next the valve, and a socket at the other end to receive the main (fig. 341). This arrangement allows the sluice valve to be removed for repair or renewal without disturbing the main.

Spindle hydrants are also connected by flanged joints, either to the flanged vertical branch from an underground main, as A, fig. 345, or to the flanged bend or elbow at the termination of a branch, as B, or to the flanged branch of a vertical fire main in the case of those fixed in buildings.

Globular fire cocks can also be obtained, screwed for connection to wrought-iron pipes, or flanged, as shown in fig. 340, No. 1.

**Testing.**—Hydrants are usually tested under a head of 600 ft. of water before leaving the works.

**Stand Pipes.**—The portable stand pipes (fig. 346), for connecting the hose to sunk hydrants, are usually of copper, with brass or gun-metal mountings, and with screwed ends sweated to the copper stems, the lower ends being arranged for connecting to the hydrants with screwed outlets or with bayonet joints. The upper ends are fitted either with single or double, fixed or revolving, outlets, and with or without screwed caps A for protection of the threads.

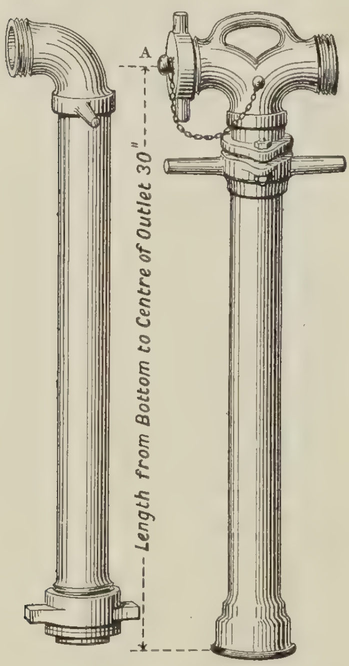


Fig. 346.—Portable Hydrant Stand Pipes

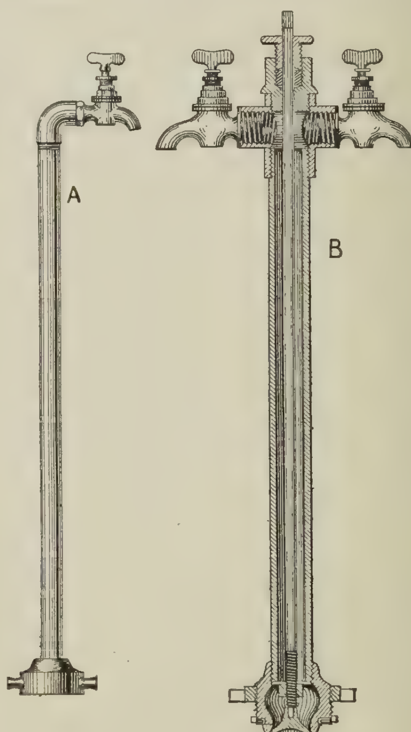


Fig. 347.—Portable Frost Stand Pipes
A, Single tap; B, Two taps.

Light portable stand pipes, with one or two draw-off taps, are supplied for attachment during frosty weather to the street hydrants. They may be obtained for attaching to the screwed outlet of a sluice-valve hydrant (A, fig. 347), or with bayonet-joint connection with central screw-spindle and stuffing-box, &c. (B), for attaching to a ball-valve hydrant.

Special stand pipes for fire purposes are required for ball hydrants, and have a vertical spindle, worked by a hand wheel at the top for depressing the ball to open the water-way (fig. 348).

**Hand or Branch Pipes.**—One end of the fire hose being connected to the hydrant (either direct or to a stand pipe), and the necessary number of hose lengths connected up, a hand or branch pipe (A, fig. 335), usually of

copper, is attached for the distribution of the water. Gun-metal jets or nozzles, varying from $\frac{3}{8}$ in. to $1\frac{1}{2}$ in. diameter, are furnished with the hand pipes, and can be quickly screwed on or exchanged according to requirements. Spreaders, adjustable distributing nozzles, and combined jets and spreaders also form part of a complete equipment, and are suitable for fire, watering, or garden purposes, as already explained.

**Fire Mains.**—A certain pressure in the mains is absolutely necessary to ensure satisfactory results, but high pressure alone will not suffice: the mains must be of sufficient capacity to maintain a full supply whilst the hydrants are at work. The diameter of the standard hose is $2\frac{1}{2}$ in., and, owing to friction and deposit in the mains, a 3-in. main is only sufficient to supply one $2\frac{1}{2}$-in. hydrant, unless the pressure is very high. A 4-in. main will supply two, and a 6-in. main four hydrants.

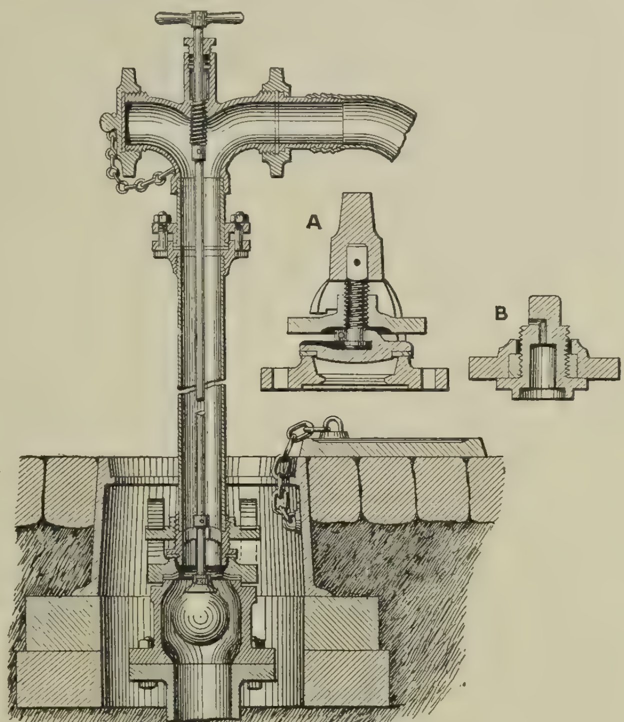


Fig. 348.—Stand Pipe for Ball Hydrants

With a pressure of 35 lb. per square inch, a 3-in. main will force a $\frac{3}{4}$-in jet to a height of about 45 ft., but this height will be reduced to about 15 ft. if a second hydrant is opened from the same main. If a double-outlet hydrant is fixed on a 3-in. main, and it is desired to use two separate streams of water, the best results will be obtained by using branch pipes fitted with $\frac{1}{2}$-in. or $\frac{5}{8}$-in. nozzles instead of the larger sizes. The same reasoning, of course, applies in the case of two adjoining hydrants fixed on the same 3-in main.

Where a single-outlet hydrant only is available, two lines of hose can be connected to it by means of a " breeching " or " Y "-piece, and it may be found that the two smaller jets, directed against points some distance apart, will be more effective than a single stronger jet acting at one point only.

For effective work a hydrant should be capable of delivering not less than 150 gal. a minute to a fire engine, or 80 gal. per minute through 150 ft. of $2\frac{1}{2}$-in. hose. Allowance must be made for the loss of pressure due to passing through the hose, which may amount to 5 or 6 lb. per square inch

for each 50-ft. length. About 80 gal. per minute can be discharged through a $\frac{3}{4}$-in. nozzle at a height of about 70 ft. with a full head of pressure of about 80 ft.

The effective pressure in pounds per square inch, for fire-extinction purposes, may vary from 25 lb. as a minimum to a maximum of 100 or 120 lb. A pressure of 25 lb. is capable of throwing a jet of water to a height of over 30 ft. through a $\frac{13}{16}$-in. nozzle at the end of one length of hose, and this may be considered sufficient for the protection of all ordinary buildings of one story. For the effective protection of two- and three-storied buildings, a pressure of from 40 to 45 lb. per square inch should be provided, and for those having four stories, not less than 55 or 60 lb. is necessary. In many towns the water is delivered at a pressure of 60 or 70 lb. which is sufficient to throw powerful jets of water to heights of 70 or 80 ft., and is therefore ample for the protection of nearly all four-storied buildings.

When these pressures are not available by gravitation, resort must be had to a manual or steam fire engine. The former will yield from 35 to 45 lb. per square inch, and should be used when the normal hydrant pressure is less than this, and when the buildings are more than two stories high.

**Pressure - augmentors.**—In the upper stories of buildings fitted with hydrants, and where the cisterns supplying these are placed in the roof, or where the pressure may be low and consequently useless for dealing with fires on the upper floors or in the roof itself, pressure-augmentors are used with great advantage. They consist of a kind of hand-pumping apparatus, which is fitted up between the hydrant and hose. On turning the wheel vigorously, the otherwise sluggish flow is delivered as a powerful jet, with a pressure equal to that obtained from a cistern placed 50 or 60 ft. above the hydrant. Water at low pressure can thus be delivered at a moderately high pressure. They can readily be attached to any existing hydrant service, and be worked by a domestic servant or other unskilled labour.

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# CHAPTER XII

## WATER-SOFTENING AND FILTERING APPARATUS

Hard waters require to be softened for many other purposes besides domestic use. As already explained, this hardness may be either temporary or permanent.

**Temporary hardness** is due chiefly to salts of lime and magnesia dissolved in the water by the agency of carbonic acid. If such water is boiled, these carbonates are decomposed, carbonic acid being driven off, and the normal insoluble carbonates are precipitated, as seen in the furring of kettles and boilers where temporarily hard water is used. The same insoluble carbonates are precipitated when hydrate of lime, *i.e.* pure slaked lime free

from carbonic acid—is added to the water, the temporary hardness disappearing almost completely in the case of the carbonate of lime and to a certain extent in that of the carbonate of magnesia. To effect the complete removal of the latter salt, a sufficient excess of lime must be added to decompose the carbonate of magnesia into the hydrate of magnesia, which is insoluble.

**Permanent hardness** is due to the presence of the sulphates of lime and magnesia in water, in which these salts are soluble without the aid of carbonic acid, and the addition of lime will not effect their precipitation.

Carbonate of soda will decompose the sulphate of lime, carbonate of lime being precipitated as before, and caustic soda (or lime mixed with carbonate of soda) will act similarly on the sulphate of magnesia. When the character of the water to be treated is known, these ingredients can be mixed in proper proportions and added in one operation. Some chlorides and nitrates also produce hardness in water.

To show the **superiority of soft over hard water**, the following extracts are taken from the Report of the Royal Commission on the Domestic Water Supply for Great Britain (1874):—

"Hard water decomposes soap, and cannot be efficiently used for washing. The chief hardening ingredients met with in potable water are the salts of lime and magnesia. In the decomposition of soap these salts form curdy and insoluble compounds, containing the fatty acids of the soap and the lime, and the magnesia of the salts. So long as the decomposition goes on, the soap is useless as a detergent, and it is only after all the lime and magnesia salts have been decomposed, at the expense of the soap, that the latter begins to exert a useful effect. As soon as this is the case, however, the slightest further addition of soap produces a lather when the water is agitated, but this lather is again destroyed by the addition of a further quantity of hard water. . . .

"The operation of washing with soap and hard water is analogous to that used by the dyer and calico-printer when he fixes his pigments in calico, woollen, or silk tissues. The pores of the skin are filled with insoluble greasy and curdy salts of the fatty acids contained in the soap, and it is only because the insoluble pigment produced is white, or nearly so, that such a repulsive operation is tolerated. To those, however, who have been accustomed to wash in soft water, the abnormal condition of the skin thus induced is for a long time extremely unpleasant.

"Ten gallons of water of the hardness of Thames water cause the waste of nearly a quarter of a pound of soap when it is used for washing."

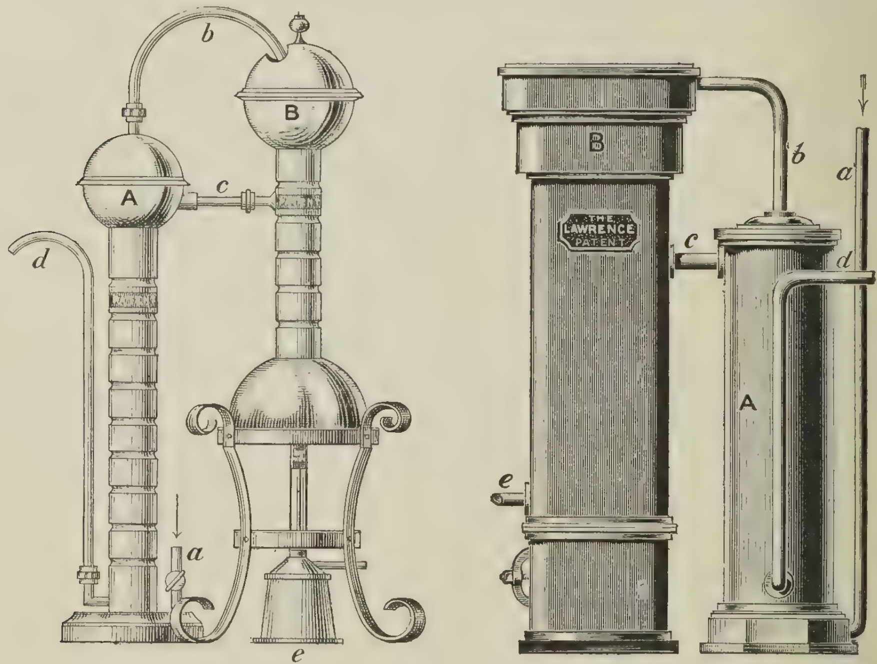
To illustrate the value of soft water for use in laundries, it may be stated that, with the best hard soap at 2*d.* per pound, every degree of hardness represents a waste of at least 1·2 lb.[1] of soap, (or 2·4*d.*) per 1000 gal. of water used. Taking the average hardness of London water at 18 degrees, and supposing it to be softened to 5 degrees, it follows that there is a saving of not less than 15·6 lb. of soap, or about 2*s.* 7*d.* for every 1000 gal. of water used.

**The Lawrence Water-softener and Sterilizer.**—The softening and sterilizing of hard and impure waters, without the use of chemicals, can be carried

[1] Some authorities say $1\frac{1}{4}$ lb.

out very efficiently, in a single operation, by means of the Lawrence patent process (figs. 349 and 350).

By the Clarke system of softening water, a deposition of carbonate of lime is effected by the addition of lime, which must be in a certain definite proportion, whereas by the Lawrence process the free carbonic acid is driven off from the soluble carbonates of lime and magnesia by a special system of boiling. The insoluble carbonates are precipitated in the form of a scale, which is easily removed, and the water does not require




No. 1, Domestic Type — No. 2, Industrial Type

Fig. 349.—The Lawrence Water-Softener and Sterilizer

A, Heat interchanger. B, Sterilizing and boiling vessel. *a*, Crude water inlet; *b*, hot-water inlet to boiling chamber; *c*, return pipe for boiling water; *d*, outlet for cold sterilized water; *e*, means of heating by gas, oil, electricity, fire, or steam.

any filtration. The boiling is effected continuously, the water being heated progressively as it passes through the apparatus, until it reaches a state of violent ebullition. It is then rapidly cooled, and leaves the apparatus at a temperature of about 20° F. higher than the crude water, and flows out soft, clear, and free from organisms. Some very resistant spores are said to be capable of surviving a temperature of slightly over the boiling-point, but experiments carried out with the Lawrence apparatus have shown that the microbes, resistant or otherwise, become encrusted by the salts of lime thrown out of solution, and sink to the bottom to be afterwards removed.

The water to be treated is conducted by the pipe *a* into the bottom of the interchanger A, and passes upwards through inner cylinders, the outer

surfaces of which are in contact with the outgoing hot sterilized water, which is flowing downwards between the cylinders and the outer casing to the outlet pipe *d*. By the time the cold water has reached the top it has acquired a temperature of over 180° F., the outgoing or sterilized water being robbed of heat to a corresponding extent. The heated crude water

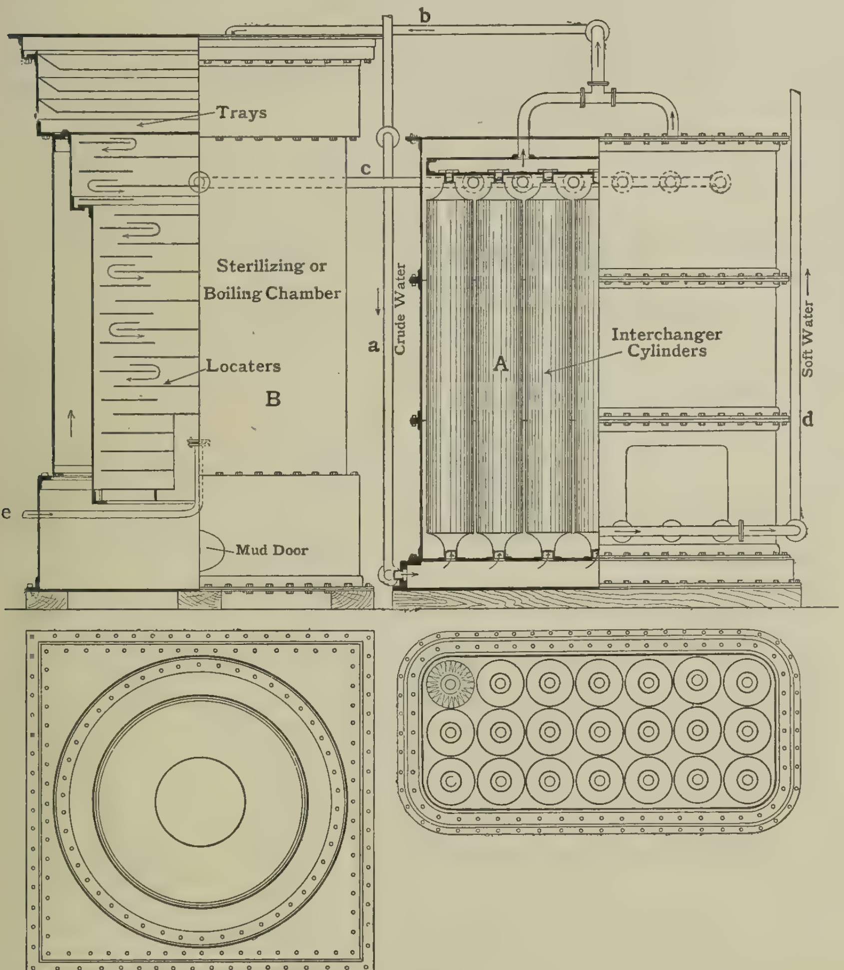



Fig 350.—Section and Plan of the Lawrence Softener and Sterilizer for 12,000 gallons per hour

is then conducted by the pipe *b* to the boiling-vessel B, which contains first a series of shallow trays (shown in section in fig. 350), and then a chamber divided into compartments by a series of plates termed "locators". Heat or steam is passed into the lowest of these compartments by means of the heater or pipe *e*, and rises, meeting the descending water and causing violent ebullition. In its passage through the boiling-vessel the gases are driven off, and the carbonates are deposited as a friable scale on the trays and locators.

The locators are in a cylinder within the boiling-vessel, and the water, on reaching the bottom, rises between the locator cylinder and the outer casing, and passes over by the pipe *c* into the interchanger, through which it passes out for storage or present use, having on its way parted with nearly all its heat to the incoming cold water. It will thus be seen that almost all the heat supplied remains in the apparatus and is utilized. Should the heated water be required for a boiler feed or for use in laundries, &c., there would be very little total loss of heat involved.

The cost of treating water is precisely the same, irrespective of the number of degrees of hardness, except that the cleaning out of the sediment would be more frequent when the water was very hard. The cleaning out is a very simple operation, the trays and locators being readily removable. There is no liquid sludge to be dealt with (as in most chemical processes), nor is there any trouble as regards the application in proper proportions of reagents. Exhaust or waste steam, if available, can be utilized in heating the water as it comes from the interchanger, thus reducing the quantity of live steam required, and should there be sufficient exhaust steam, the apparatus can be worked entirely by it.

If sufficient permanent hardness is left in the treated water to justify its removal, treatment with carbonate of soda can be employed after heating and recooling. In the majority of cases, however, the simple boiling ensures a satisfactory water for boiler feed, and with certain waters a considerable proportion of sulphate of lime, as well as the carbonates, is precipitated during the boiling process.

**The Lawrence Patent "Military Pattern" Portable Water-sterilizer**, recently introduced for military purposes, is simple and compact, easy and economical to work, and rapid in action. It can be supplied either (*a*) packed in a galvanized steel tank (2 ft. 10 in. by 2 ft. by 1 ft. 3 in. inside), holding about 44 gal., which serves to receive the treated water as it leaves the apparatus; or (*b*) to travel at the back of a service water-cart, in upright position, at the right height to deliver the sterilized water into the cart. The apparatus, with lamp and supply tank, weighs 1 cwt., that of the steel case being 2 qr. 24 lb., and the discharge is about 2 qt. per minute.

The water first passes into the heat-interchanger, and, rising inside the corrugated copper cylinder, is brought to a temperature of about 190° F. before entering the sterilizing chamber, thereby saving about six-sevenths of the heat otherwise required to raise the cold water to 212° F. As the water leaves the heat-interchanger it passes through a float valve, which closes at once if the temperature from any cause falls below 212° F. As this valve cannot be tampered with without taking the apparatus to pieces, nothing but sterilized water can pass. The water is kept at boiling-point for a few seconds only, and then returns to the heat-interchanger outside the copper cylinder, where it is rapidly cooled, leaving the apparatus at an average temperature of 15° F. above that of the crude water.

The lamp, which will burn about three hours with one filling, is fixed beneath the bottom of the sterilizing chamber, and has a maximum consumption of 1½ pint of ordinary paraffin oil per hour.

If the heat-interchanger is empty it will take about fifteen minutes from

the time the lamp is lighted before the sterilized water begins to flow; but, if full, the water will be delivered immediately. A small quantity of boiling water can be drawn off from the sterilizing chamber at any time.

The Lawrence Patent Portable Water-sterilizer for Travellers in the Tropics differs from the "Military" type in being packed in a smaller case (2 ft. by 1 ft. 3 in. by 9 in.), and having no supply tank, being fed by means of a flexible pipe. Its capacity is about ½ pt. per minute continuously, or 4 gal. per hour, and the weight of apparatus and lamp complete is about 36 lb.

After a series of tests, Drs. C. Wood and F. Lewis, in December, 1904, reported most favourably on the Lawrence apparatus at Leavesden Asylum.

**Maignen's Water-softening Apparatus** (fig. 351) is automatic in action and well adapted for domestic supplies. It is made in stock sizes to soften from 100 to 3000 gal. of water daily, and in larger sizes to order. The makers supply the reagents for softening the water in the form of a powder, to which they have given the name "Anti-calcaire". This is placed in the automatic feeder B. The inlet water, after passing through the ball valve E, is discharged over a wheel, which is geared to the automatic feeder and regulates the quantity of powder falling into the mixing cone C; in this cone the powder and water are intimately mixed, and pass thence into the softening tank A. The solid matters are precipitated in this tank, and the softened water overflows into the filtering chamber D, from which it can be drawn off through the outlet valve or stop cock F. The two valves G G are opened only for flushing-out the two compartments of the tank. It is said that "the only attention required is to recharge the hopper once a week, fortnight, or month, and flush out the tanks and filters every three months".

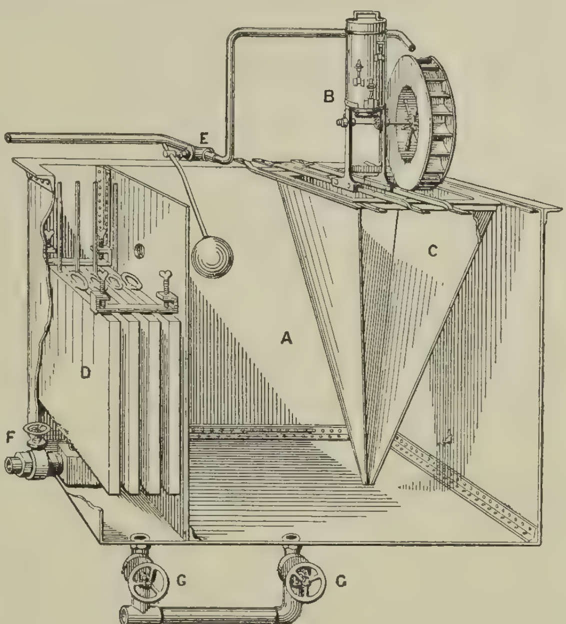


Fig. 351.—Maignen's Water-softening Apparatus

**The Atkins Patent Automatic Water-softener** is an improved adaptation of the well-known Clarke system of softening water by means of lime, no soda or other objectionable reagent being employed. No skilled labour is necessary, and there is nothing to wear out in the apparatus, which consists of the following parts, with the necessary fittings and connections:—

*An Inlet Cistern and Float-controlled Dividing Valve,* to divide the

outflowing water into two streams, one of which goes to the lime-water cylinder and the other to the mixer;

*A Lime-water Cylinder*, in which a portion of the hard water from the dividing valve is made into clear lime water at a uniform rate, sufficient cream of lime being put in overnight for the next day's use;

*A Mixer*, into which the remainder of the hard water from the dividing valve flows, and in which it meets and is mixed with the clear lime water overflowing from the lime-water cylinder;

*A Softening Cistern*, in which the process of softening and clarifying takes place. This cistern is fitted with an open collecting trough or pipe, which extends across the upper end, and receives the softened water as it rises, and conveys it to the float storage cistern.

The action is as follows. The water flows into the inlet cistern, and in passing through the dividing valve is split into two streams, one of which flows direct to the mixer, and the second but smaller stream into the lime-water cylinder, which, being always full, immediately overflows into the mixer, the proportion of lime water being regulated by the dividing valve. From the mixer the combined waters flow into a funnel, which carries them to the bottom of the softening cistern, where the softening action takes place. As the water rises it clarifies and overflows at the top, clear and soft, into the storage cistern, which contains the float operating the dividing valve. If water is drawn from this cistern, the float falls and opens the dividing valve, thus starting the plant. When the draw-off ceases, the inflowing water raises the float, shuts off the dividing valve, and stops the plant. The whole apparatus is thus automatic, and only requires that the spent sludge should be run to waste once a day, and a fresh supply of cream of lime put in.

The system is particularly suitable for treating waters from the chalk, mountain limestone, and red sandstone, &c. In different parts of the country, waters of the hardness stated have been reduced as follows:—

| | | | |
|---|---|---|---|
| Scotland | ... | 13° to 3° (grains per gallon), | Mountain limestone. |
| Suffolk | ... | 22° to 5° ( „ „ ), | Chalk. |
| Sussex | ... | 26° to 12° ( „ „ ), | Wealden. |

**The "Criton" Water-softener** (fig. 352), in which lime and soda are used, is made by the Pulsometer Engineering Company. The details of the apparatus are clearly shown in the illustration. The softened water, after leaving the settling tank, passes through a filter, which can be cleansed by a stream of water from the wash-in valve, rising up to the filter wash-out, the ordinary inlet and outlet valves of the filter being closed.

In the **Archbutt-Deeley Process**, for which Messrs. Mather & Platt are the sole licensees, lime and soda are used, and are thoroughly mixed with the water by means of steam and air forced through perforated pipes in the tank. As some softened waters are liable to form deposits in pipes and in the feed apparatus of steam boilers, unless carbonated, the effluent is in this process carbonated by fuel gas forced into it by a steam blower.

**The "Reisert" System** of softening, purifying, and clarifying water has recently been introduced into this country by Messrs. Royle, Ltd., of

Irlam, Manchester, the licensees and manufacturers for the United Kingdom. Lime and soda are used in the softening process, and, as is the case with nearly all the special systems of filtration to be described, the filtering material can be cleansed without removal.

**Filtration of water** through layers of sand and fine gravel is one of the best methods of purifying it on a large scale, and is the system usually adopted by authorities supplying water which without some such treatment would be unsuitable for consumption. It is usual to strain it first to remove the coarser impurities, then to give it a period of rest in settling tanks to allow the finer matter held in suspension to fall to the bottom as sediment, and finally to pass the partly clarified water through the filter beds. The depth of the sand and gravel is as a rule about 3 ft., but varies according to circumstances.

After being a few days in use a jelly-like scum forms on the surface of the sand, and is found to be composed of a mass of living organisms which prey upon and destroy all, or nearly all, the organic impurities and the bacteria of water-borne diseases which may be present. The water drains away at the bottom, and is led into the service reservoirs for distribution. Filtration through sand, however, does not eliminate the impurities held in solution, nor does it remove metallic pollution or those salts which impart hardness to the water. Various processes for purifying polluted water are in more or less successful operation, some of them mechanical, some chemical, and others a combination of the two.

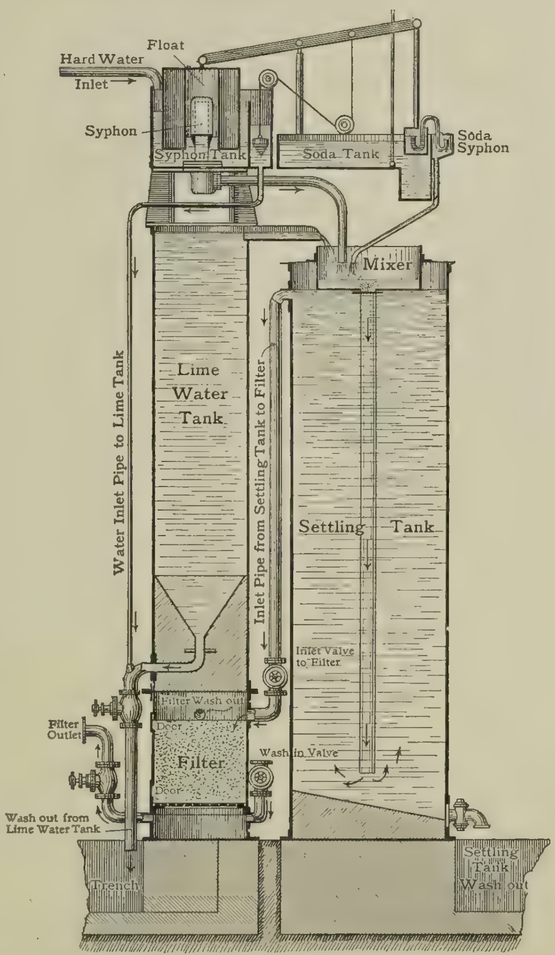


Fig. 352.—The "Criton" Water-softener and Filter

The objections to most chemical processes are that they necessitate having to deal with a mass of liquid sludge.

**Candy's Patent Automatic Compressed-air and Oxidizing Filters**, in which

polarite and sand form the filtering media, are adapted for purifying water on a large scale. They automatically compress air into the water, saturating it with dissolved oxygen previous to filtering it. The cost of cleaning and working, including upkeep, is said to be about 1*d*. per 50,000 gal., for a town's supply of over 1,000,000 gal. a day. Batteries of these filters may be placed on trunk mains without any appreciable loss of head.

According to a recent analysis of water supplied for use at Hastings and St. Leonards, where there is an installation of ten of these filters, practically the whole of the free and albuminoid ammonia, as well as the iron in solution, had been removed, and this without the addition of any chemicals. The exact treatment depends upon the quality of the water to be dealt with.

**Riddell's Filters** consist of closed iron vessels filled with fine sand, through which water is forced at a considerable pressure. The filter can be cleansed by reversing the valves and forcing a strong current of water from below. The coarser materials are easily removed from the water, but when bacteria are suspected a finer filtration is necessary.

**The Patent Gravity and Pressure Filters** manufactured by Messrs. Mather & Platt consist of circular iron tanks or closed cylinders, the filtering medium being pure quartz crystals crushed and graded to suitable sizes. Sterilization of the quartz beds is effected by forcing live steam through them after washing out.

The Pulsometer Engineering Company manufacture the "**Torrent**" **Patent Filter**, formed of cast or wrought iron, containing layers of filtering material suitable for the water to be treated. Cleaning is done by admitting a reverse current of water and air at high pressure, the latter being obtained from the steam-blower, which is supplied with the filter.

**Iron in Water.**—Iron, which is so objectionable in water for domestic purposes on account of its taste and tendency to stain linen washed in it, is precipitated by exposure to the air and light, and is partly removed by filtering the water through alternate layers of coke and sand. Iron present in water containing organic matter, favours the growth of a fungus which tends to choke the filters and the pipes through which it flows.

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# CHAPTER XIII

## HOUSEHOLD FILTERS

**The object to be attained** in the purification of water for domestic purposes is the removal of all organic matter, the removal or destruction of all micro-organisms, and, when necessary, the removal of those mineral salts which cause hardness. The water may be comparatively pure, or filtered efficiently at the source of supply, but there is always the risk of its becoming contaminated between that point and the tap from which it is drawn for use on the consumer's premises. More especially is this the case when there are open storage cisterns in the house itself.

Whilst complete sterilization of water for domestic purposes can only be ensured by distillation or boiling, both processes being inconvenient and costly when applied on a large scale, there are other methods of purifying water of doubtful quality which have been found more or less successful in practice. Many of the old types of domestic filter are, however, practically useless for continuous satisfactory working, owing to the difficulty of ensuring the periodical examination and cleansing of the apparatus.

**The Atkins Filters.**—The *Atkins New Carbon "Candle" Filter* (fig. 353) claims to be germ-proof, and to remove all organic matter. The water supplied to the upper chamber percolates through a series of hollow "candles", which are made of pure charcoal, and can be readily cleansed when necessary. The filters can be obtained of 2, 4, or 6 gal. capacity.

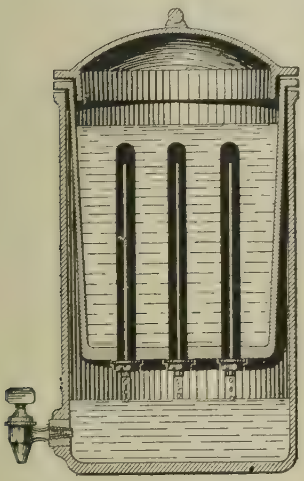

Fig. 353.—The Atkins New Carbon "Candle" Filter

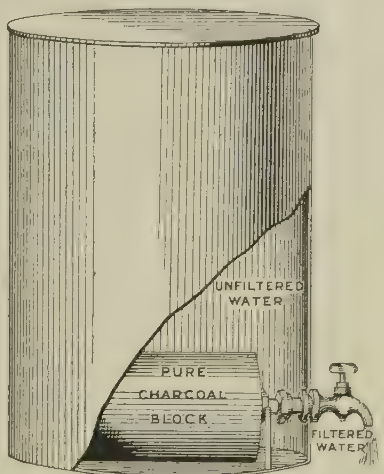


Fig. 354.—The Atkins "Safety" Filter

In the *Atkins "Safety" Filter*, a charcoal filtering block, fitted on a central tube, is placed in a movable pan, and double filtration can be secured by first passing the water through a loose bed of granulated charcoal placed around the block. The loose charcoal can be emptied out for cleaning, and the impurities on the surface of the block can easily be brushed off. These filters are made of stoneware, in sizes from 1 to 10 gal.

A special form of this filter is made of galvanized iron, 18 in. high and 12 in. in diameter (fig. 354), in which is fitted a block of pure charcoal fitted on a central tube, and giving a filtering surface of nearly 200 sq. in. This yields about 10 gal. per hour, and, as the water is filtered as it is drawn, it is fresher than when stored after filtration. The filtering block can be easily removed and cleaned, and this should be regularly done.

The *Atkins Charcoal-block Cistern Filters* may be used singly, or in sets of two or more coupled together, and placed in the cisterns (fig. 355). Each perforated cylinder contains a central perforated tube passing through charcoal blocks, and the space between the latter and the cylinder is filled with granulated charcoal. The filtration goes on from the whole surface,

first through the loose charcoal, and then through the solid block into the central pipe, from which it passes out to the delivery pipe. A cap is screwed on the dead end of the central tube, and can be removed for repairs or renewals.

The *Atkins Compound Filtering Apparatus* is recommended for purifying water containing much suspended matter. It consists of a cistern with two compartments, one of which is fitted with a perforated tray, on which a bed of granulated filtering material is placed, and above this one or more cistern filters are fixed as described above. The unfiltered water is admitted by means of a ball cock into one compartment of the tank, and rises in the second or filtering compartment, passing through the preliminary filter bed, in which it deposits the grosser impurities, and then

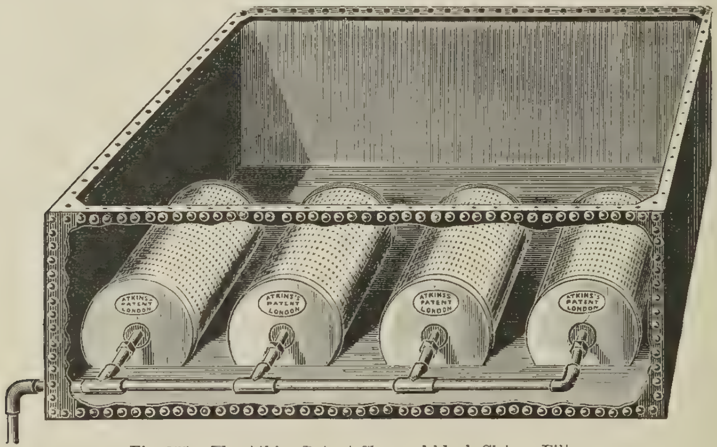


Fig. 355.—The Atkins Patent Charcoal-block Cistern Filters

through the charcoal blocks. The granulated material can be cleansed by flushing as often as considered necessary, by opening the "Waste" and allowing the water in the cistern to run, and the charcoal blocks can be cleaned by scrubbing or scraping, without removal from the cistern.

This form of filter can be used, without the charcoal blocks, for clearing the hot-water supply to baths, &c., which sometimes becomes turbid after passing through the boiler, owing to the presence of iron in solution.

The Atkins filters described above are non-pressure, but the Company manufacture high-pressure filters on somewhat similar lines, including small "tap filters".

**Charcoal.**—In whatever form charcoal is used as a filtering medium, it is absolutely necessary, to ensure satisfactory results in working, that it should be more or less continuously aerated and periodically renewed. If kept constantly under water it becomes a source of danger, owing to the mass of living organisms which collect and are further propagated in it.

A convenient form of domestic filter is shown in fig. 356, which, whilst

affording a constant supply of filtered water, at the same time ensures a frequent aeration of the filtering material. The upper cistern receives the water to be treated, and contains the filtering material, through which the water passes into the storage cistern below, through a series of perforations in its bottom. The ball cock A regulates the supply of water to the upper cistern, shutting off the supply temporarily if it comes in more quickly than it can pass through the filter. When the lower cistern becomes full, its ball cock B comes into action by rising and shutting off the supply from the rising main to the upper cistern altogether. The upper cistern then gradually empties itself, the water contained in it passing through into the storage cistern, and fresh air following the water downwards through the charcoal, aerating it and oxidizing the putrescible matter collected.

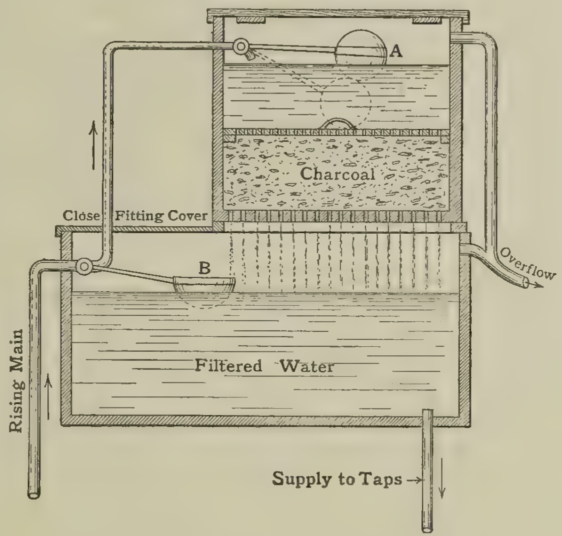

Fig. 356.—Domestic Filter

After a certain amount of water has been drawn off, the ball will fall in the storage cistern, allowing a fresh supply to be delivered for treatment. The action is thus automatic, and it is only necessary to ensure the renewal of the filtering materials at intervals, which will depend on the amount and nature of the deposit.

**Relative Efficiency of Water-filters.**—A most valuable and exhaustive series of experiments was carried out some years ago by Dr. Sims Woodhead, M.D., F.R.S.E., and Dr. G. E. Cartwright Wood, M.D., B.Sc., and the results were published in *The British Medical Journal* (Nov. and Dec., 1894, and January, 1898), in a series of articles entitled "An Enquiry into the Relative Efficiency of Water-filters in the Prevention of Infective Disease". The articles have been reprinted in book form.

More than twenty of the best known filters in general use were tested, with the result that the majority were found quite untrustworthy as regards their power to prevent the passage of disease germs into the filtrate. Filters which had been relied on for years were proved to be a delusion and a snare, making "good water bad and bad water worse". Many were found to act more or less efficiently as strainers, clearing the water from turbidity and ordinary solid matter held in suspension, but permitting the ready passage of micro-organisms through the filtering material.

Not only so, but the filtering media became culture beds for all sorts of bacterial life, the numbers increasing daily at a most alarming rate. As cholera, enteric, and certain other diseases are known to be caused by disease

germs in drinking water, a filter, to be efficacious, must prevent the passage of germs. Chemical examination alone, which used to be relied on, is not sufficient to establish the absolute purity of a water.

The method adopted in carrying out these investigations was that of direct experiment. Not only were the filters tested as regards their power of removing the organisms (harmless or otherwise) existing in the water, but other tests were made with similar water to which pathogenic organisms had been added, and also with sterilized water containing the bacilli of cholera and enteric.

The following materials and combination of materials were used in the construction of the filters tested by Drs. Woodhead and Wood:—

1. *Carbon* in its various forms, either pure or compounded with some other chemical substance; for example, the silicated or manganous varieties:
   (*a*) As blocks, or in the powdered or granular form, used either separately or in combination; for example, *Doulton's Manganous Carbons, Morris's Patent "Circulating" Filter;*
   (*b*) *Charcoal* as fine powder, deposited on asbestos cloth, or placed in the interior of a stone block; for example, *Maignen's Filtre Rapide; Barstow's Filter.*
2. *Iron* in the form known as *spongy iron*, or as *magnetic oxide*; either
   (*a*) Alone; for example, *Spencer's Magnetic Filter;* or
   (*b*) Along with asbestos cloth; for example, *Spongy Iron Company's Filter.*
3. *Asbestos* in various forms, either
   (*a*) As a film of compressed asbestos pulp; for example, *Nibestos Filter.*
   (*b*) As asbestos cloth, on which fine charcoal or magnetic oxide is deposited; for example, *Lipscombe's New Patent Cylinder Filter, Spongy Iron Company's Filter;*
   (*c*) As a fine deposit on cellulose discs; for example, *Piefke Filters*, or
   (*d*) As porcelain manufactured from finely powdered asbestos; for example, *Porcelaine d'Amiante Filter.*
4. *Cellulose*, either
   (*a*) As discs of compressed cellulose; for example, *Piefke Filters*; or
   (*b*) As compressed cellulose, with a fine deposit of asbestos pulp; for example, *Piefke Filter.*
5. *Porous Stone* (artificial or natural); either
   (*a*) Alone; for example, *Doulton's Stone Bottle Filter, Duff's Patent Germ-proof Filter*; or
   (*b*) With other substances, such as powdered carbon; for example, *Barstow's Tap Filter.*
6. *Forms of Prepared Porcelains* from clays or pastes; for example, *Pasteur (Chamberland) Filter, Pukall Filter.*
7. *Compressed Siliceous or Diatomaceous Earths*; for example, *Berkefeld Filter.*

It was found that the only non-pressure or table filters which did not directly transmit disease germs were the Pasteur (Chamberland), the Berkefeld, and the Porcelaine d'Amiante. The pressure filters which did not allow disease germs to pass into the filtrate were the three mentioned above, and the Pukall, Slack and Brownlow's Porcelain, and Duff's Patent Germ-proof Filters.[1]

The Porcelaine d'Amiante filter, in which the water is passed through extremely fine porcelain containing finely powdered asbestos, was the most perfect, but the rate of filtration was rather slow.

[1] It must not be forgotten that these experiments were carried out from 1894 to 1897, and that improved filters are now made by many of the firms whose filters were then tested.

In the Pukall and Slack and Brownlow's filters the water was filtered through unglazed porcelain. In Duff's filters the filtering material was a natural stone, the walls being about 1 in. thick; but the stone was liable to break when heated for sterilization. Filtration was very rapid at first, but the output soon diminished, owing to the deposition of suspended matters on the surface. This, however was easily brushed off, but prolonged experiments could not be carried out to establish how long the output could be maintained.

For domestic filtration, therefore, the **Pasteur (Chamberland) and Berkefeld Filters** would appear, from these experiments, to be the most satisfactory, the latter giving the larger output, and being more easily cleaned, but more fragile. The two are somewhat similar in general appearance, being hollow, candle-shaped tubes, closed at one end, and furnished with a nozzle attached to the other end, through which the filtered water flows after having passed through the sides of the tubes from the outside to the interior. When used as pressure filters, and attached to taps, they are enclosed in a case having an annular space into which the unfiltered water is delivered from the tap. The Pasteur nozzle discharges at the lower end, while the delivery from the Berkefeld passes upwards through the top of the case. The Pasteur candles are made of uniform size, but those of the Berkefeld pattern are obtainable in various sizes, and are thicker but more porous.

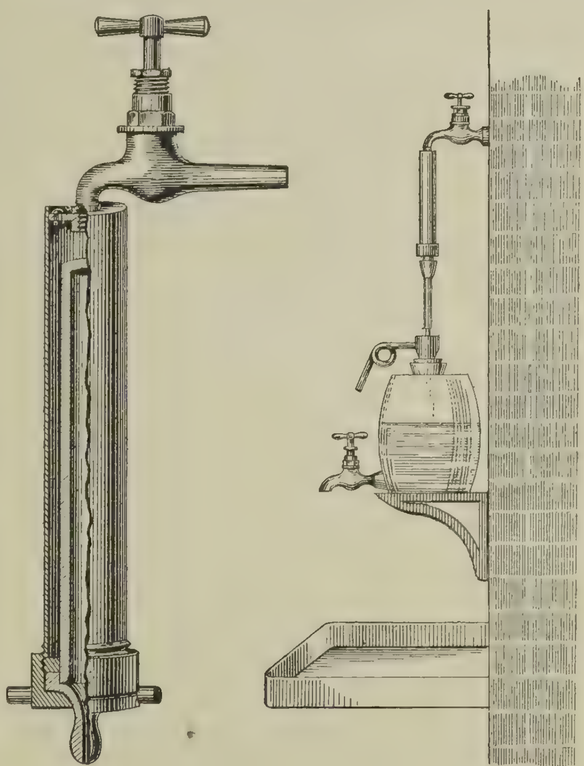

Fig. 357.—Pasteur (Chamberland) Filters attached to Taps

The best results with each are obtained when they are arranged to work under pressure, by attaching them to taps, as shown in fig. 357 and 358. The pressure may be that due to a cistern in the roof, or that in the main itself, the output varying with the pressure. When the pressure exceeds 45 lb. per square inch for certain filters, it is desirable that reducing valves should be inserted.

When an insufficient pressure is obtainable from the cistern or main, to ensure an adequate supply of filtered water the filter can be

attached to a small semi-rotary or other force pump specially made for the purpose.

With an ordinary water pressure of 30 lb. per square inch, a Pasteur candle should give an output of at least 8 gal. per day, that from a Berkefeld filter being much more; without pressure, the ordinary rate of filtration from a Berkefeld candle is about 1 pint per hour. Where pressure is not available, or is undesirable, the output is so small that it is necessary to use a number of candles, their arrangement depending on the amount of water required.

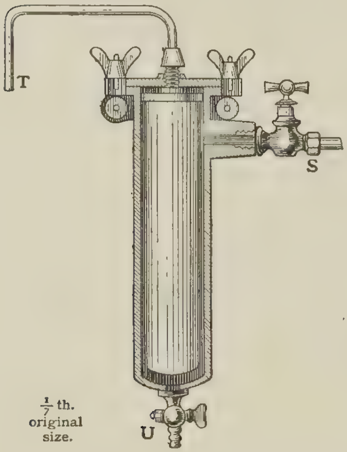


Fig. 358.—Berkefeld Filter attached to Tap

S, Inlet tap; T, Filtered-water outlet; U, Flushing tap.

Fig. 359 shows one of the **Pasteur Non-pressure Cistern Filters** placed in an ordinary cistern. It consists of a galvanized iron frame with a series of filter tubes connected by strong elastic collectors, and carried in a galvanized wrought-iron cage. The main collector, to which the others are connected, passes through the cistern, and is attached on the outside to a siphon pipe furnished with cocks for permitting the flow of filtered water and rejecting the air on starting. In this way a siphon action is set up, and the head of water in the filter is thus constantly increased by the difference between the legs of the siphon so formed. A considerable

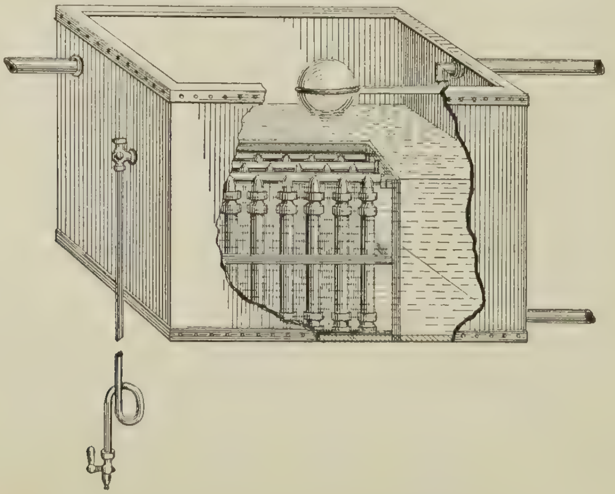

Fig. 359.—Pasteur Non-pressure Cistern Filter

output is thus obtained, and supplies up to 500 gal. per day can be provided.

Stoneware non-pressure filters, both Pasteur and Berkefeld, for house or office use, have an upper compartment (for the unfiltered water) in which

one or more candles are fitted to communicate with the lower compartment, which forms a small reservoir for the filtered water, and from which the water is drawn through a tap.

**The Berkefeld Large-supply Filters** (fig. 360) are intended for attachment to the main or cistern supply so as to work under pressure. They can be obtained in enamelled cast iron or tinned copper, in sizes to supply from 20 to 550 gal. per hour under a water-pressure of 45 lb. There is a certain amount of risk in using these batteries of candle filters when placed in cisterns, owing to defective connections allowing unfiltered water to pass and thus defeat the object in view.

As a rule it is unnecessary to filter the whole of the water required in

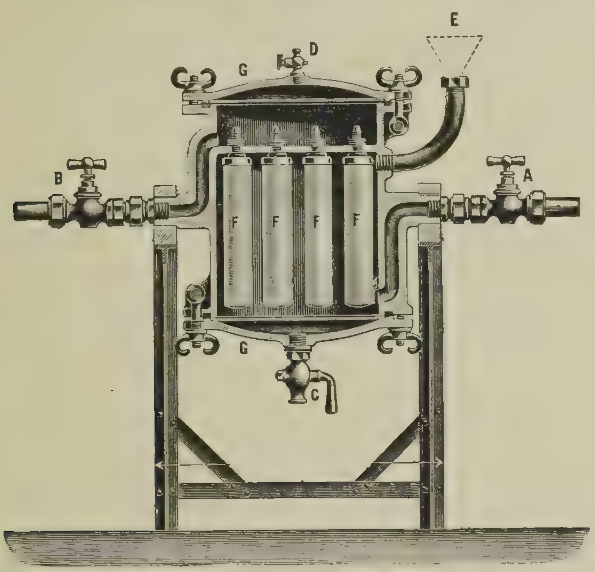


Fig. 360.—The Berkefeld Large-supply Filters

an ordinary household. One or two filter taps, from which to draw the water required for drinking or cooking purposes, will usually suffice.

**How to Cleanse the Berkefeld Filter.**—When the output becomes reduced through the coating which forms on the surface of the cylinders, it is necessary to cleanse them. This process is greatly facilitated if, after each cleaning, a mixture of Kieselguhr powder and water is poured into the filter case. This forms an even coating on the cylinders, on which the impurities from the water collect, and which is easily washed off.

To clean the filters of the type shown in fig. 360, the inlet tap A and outlet tap B are shut, and the flush tap C slightly opened. Air is forced in by means of an inflator, connected by tubing to the air cock D, driving the filtered water remaining in the cylinder backwards, in which way the Kieselguhr coating, with all its collected impurities, is thrown off. The case is then well flushed out by opening the taps C and A, after which it is emptied by shutting A and opening E, when the filter can be recharged. This is done by pouring in a small quantity of the Kieselguhr powder,

mixed with water, at the inlet E, screwing on the cap and turning on the tap A, when the incoming water spreads the powder uniformly over the surface of the cylinders.

After a time this system of cleaning becomes less effective, and the cylinders should then be taken out and replaced by a new set if necessary, whilst the dirty ones are being properly cleansed and re-sterilized by being placed in a clean vessel with cold or tepid water, boiled for an hour, and then carefully dried.

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